Compressed Air Magazine

JULY 1944

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VOLUME 49 • NUMBER 7

NEW YORK • LONDON

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Write for Bulletin 135-9

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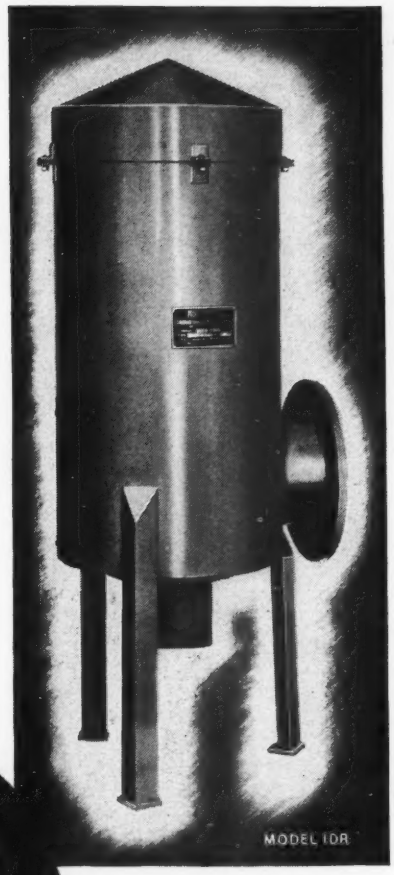

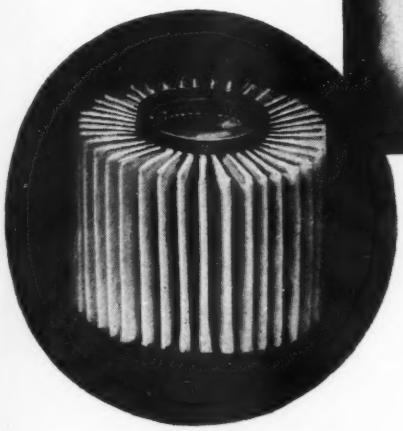

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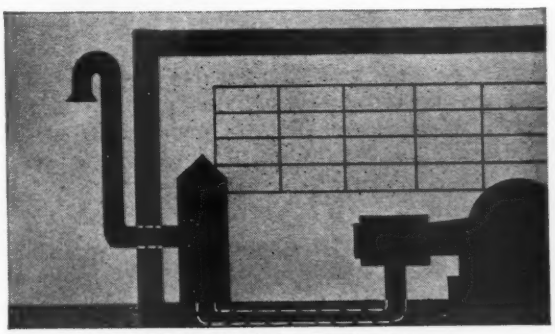
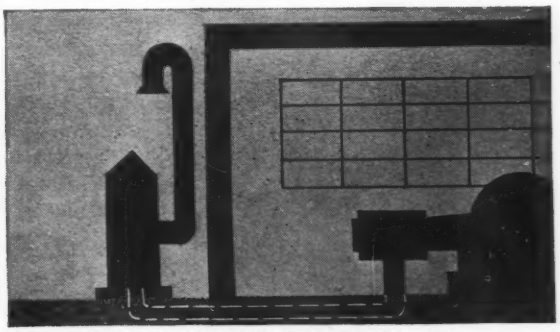


Model IDR INSIDE Engine Room



Model IDR OUTSIDE Engine Room

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Smooth; easy to apply; readily fills all clearances. Non-settling. Packed 1 and 7 lbs., ready for use.

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No other loader can name the numerous advantages listed herein:

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RockerShovels cover a full size range of individually designed machines. Capacities from 1 to 4 tons per minute. Careful engineering for each application assures the user of maximum performance.

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3. Easy to operate—
Competitive tests, among other things, have shown the RockerShovel to be unanimously preferred by operators. Easy to swing, instantaneous response to the touch of control handles, no shock transmitted to the hands and wrists of the operator.

4. Rugged construction—
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These are the qualifications that make a loader a RockerShovel.

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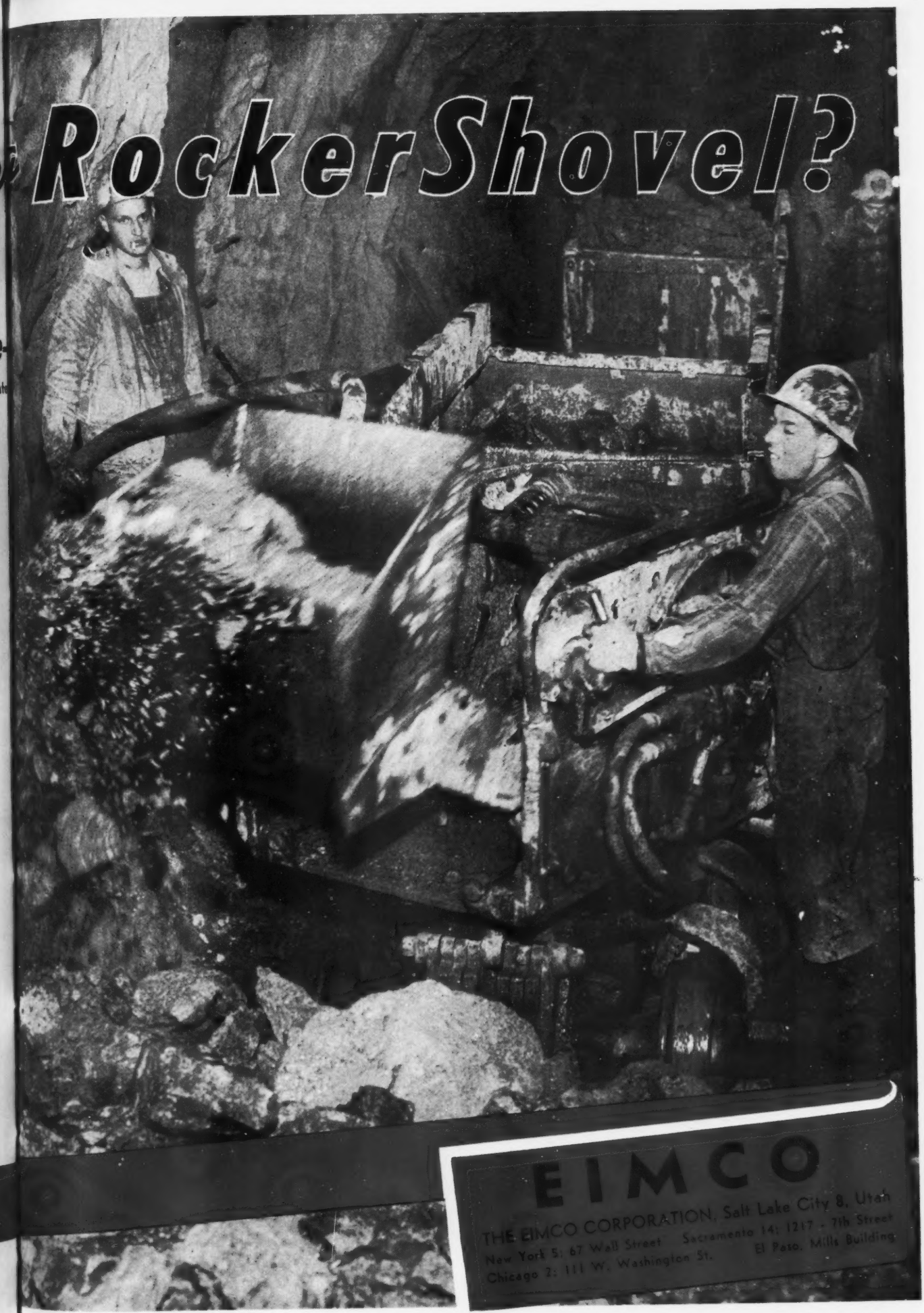
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*Hardest material made by man

ON THE COVER

IN THE early days of mining magnetite iron ore in the Adirondacks, huge pillars were left to support the overlying rock. After a recent extensive study with microseismic, subaudible-noise recording instruments by representatives of the U. S. Bureau of Mines, it was determined that all of them were not needed. The pillars are of solid magnetite, and some of them range up to 200 feet in height and contain as much as 30,000 tons of the mineral. The removal of the unnecessary ones is adding at least half a million tons of iron ore to the war effort. Our cover picture shows two miners starting to cut through the top of one of these pillars where it joins the roof. The men must carry all the drilling and blasting equipment, oftentimes up a ladder, and consequently prefer to use light drills that are easy to hold. The Jackleg is a pneumatic mounting that supports the drill and also feeds the steel into the rock. The operator is required only to hold down the handle of the drill with slight pressure and is relieved of the need of exerting any forward thrust. Faster drilling with less fatigue results.

●

IN THIS ISSUE

EVERY American schoolboy knows a Liberator when he sees one, and it is a fair assumption that millions of persons in Europe also can identify the plane readily by this time. It's a familiar sight on every battlefront and even over the sea lanes, where its exceptionally long range makes it valuable for submarine-patrol duty. Many of these monster bombers and their companion transports are turned out in the nation's largest aircraft plant at Fort Worth, Tex. Our leading article describes the manufacturing operations there.

●

IT GOES without saying that no part of a ship is more important than its propellers, for without them it would be helpless. It can also be said that no part is engineered and manufactured with greater care and precision. Making them is a specialty business in which certain firms excel by reason of their familiarity with the problems involved. One of these concerns is the Cramp Brass & Iron Foundries Division of The Baldwin Locomotive Works. From its foundries and machine shops come bronze propellers for many types of craft. Their casting is described by Robert G. Skerrett.

●

A TWO-page article tells how drifter drills and pneumatic columns have been used on several western shaft-sinking jobs. Two pages of photographs illustrate some of the diversified applications of compressed air.

●

A CORRECTION

IN THE article on the Denison Dam in our May issue is a typographical error at the bottom of the center column, page 113. The text should read: "An upstream blanket and downstream berms involved the placing of an additional 2,000,000 cubic yards of earth."

Compressed Air Magazine

VOLUME 49 **July, 1944** NUMBER 7

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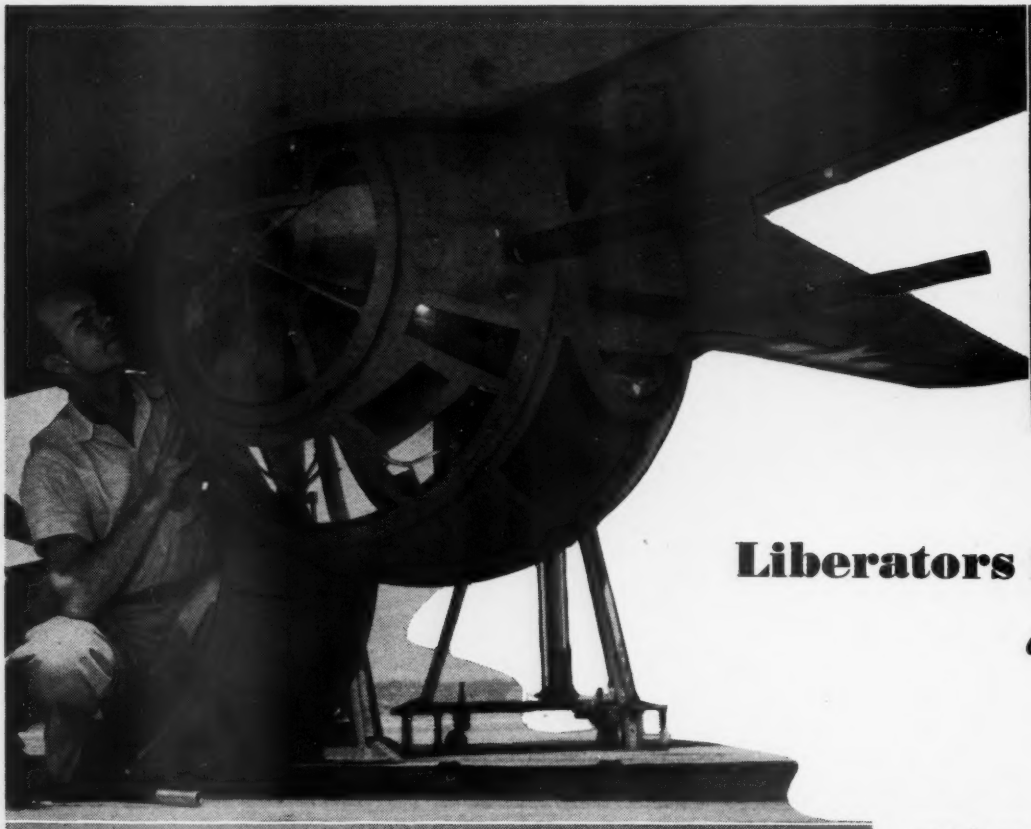
A monthly publication devoted to the many fields of endeavor in which compressed air serves useful purposes. Founded in 1896.

CCA Member Controlled Circulation Audit.

Published by Compressed Air Magazine Co., G. W. MORRISON, *President*; C. H. VIVIAN, *Vice-President*; F. E. KUTZ, *Secretary-Treasurer*
Business, editorial, and publication offices, Phillipsburg, N. J.
Advertising Office, 11 Broadway, New York 4, N. Y, L. H. GEYER, representative.
Annual subscription: U.S., $3.00; foreign, $3.50. Single copies, 35 cents.
COMPRESSED AIR MAGAZINE is on file in many libraries and is indexed in Industrial Arts Index.



Liberators from Texas

C. H. Vivian

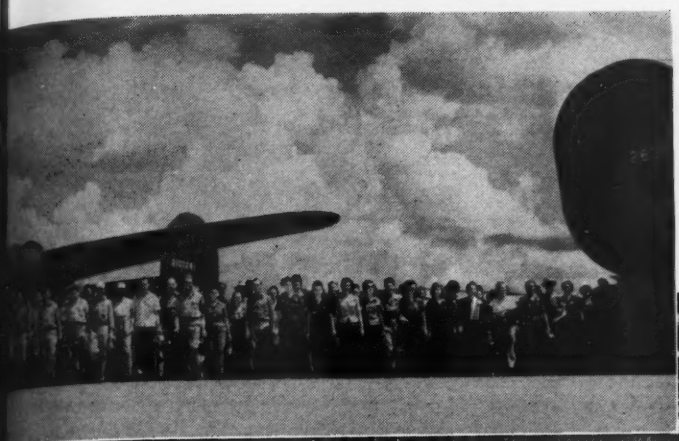
COURIERS OF VICTORY

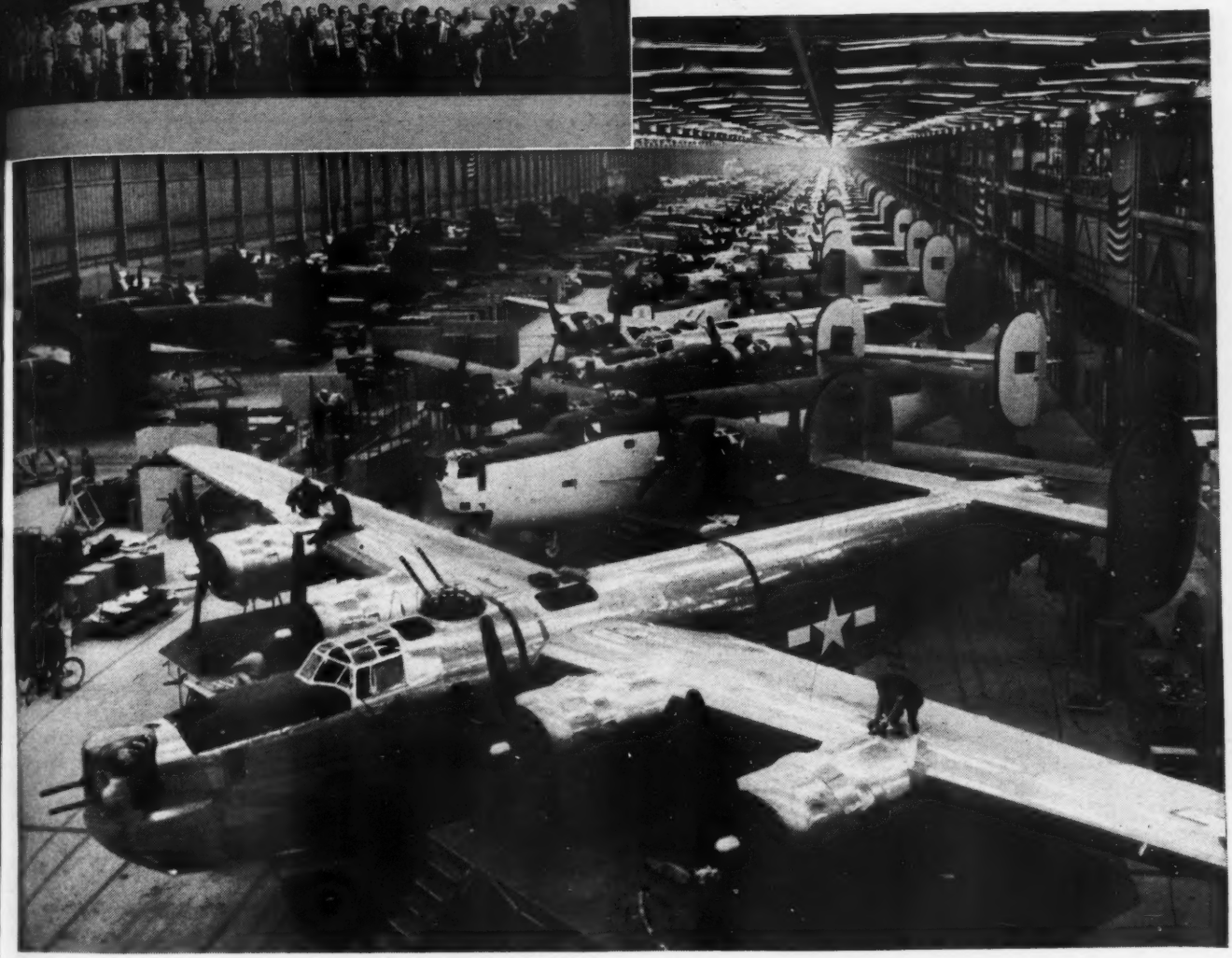
At the bottom is a B-24 bomber ready for combat. In recent months its firepower was increased by the addition of a nose gun turret. The top, tail, and belly turrets also show in this picture. Each turret carries two 50-caliber machine guns, and the plane has four fixed waist guns of the same size. An extra belly gun can be installed, making thirteen in all. The retractable Sperry ball belly turret is seen at the top. In the center are a few of the thousands of employees of the Fort Worth plant grouped with one of the C-87 Liberator transports they help to build.

MANY of the Liberator bombers that are streaking through the skies over enemy-held positions came off the assembly line of the Consolidated-Vultee Aircraft Corporation's huge manufacturing establishment at Fort Worth, Tex. Although it has not received as much publicity as some other aircraft plants, it is claimed to be the nation's largest and to have the longest double production line in existence. The 117-acre factory holds a slight margin in floor space over the Ford Motor Company's Willow Run plant, which also builds Liberators. It is one of eleven Consolidated-Vultee factories which, collectively, turned out more pounds (126,000,000) of aircraft last year than any other manufacturer. The production volume of the Fort Worth colossus is, of course, a military secret.

The Liberator is a 30-ton, all-metal plane powered by four Pratt & Whitney 1200-hp. radial-type engines. It has a top speed of more than 300 miles an hour and a cruising speed of 200 miles. Its wing span is 110 feet, its wing area 1040 square feet, and its wing loading 50 pounds per square foot. It is 66 feet 4 inches long and 17 feet 11 inches high. Its service ceiling is above 35,000 feet. It carries 4 tons of bombs in addition to a full crew, and can fly faster and farther when so loaded than any other bomber of its size now in service. Last August a fleet of Liberators flew 300 tons of bombs to the Ploesti oil field in Rumania, covering 2400 miles, the longest flight ever made in a war zone. However, the craft has a range of more than 3000 miles. A Liberator holds the transatlantic-crossing record of 6 hours 40 minutes. It gets its great lifting power and high speed from its Davis wing section, which is narrower and shorter than that of most planes in its size range.

The British named the craft Liberator and have used it effectively in patrolling the sea lanes for submarines. The U. S. Army calls it the B-24 bomber, for which service it is equipped with four turrets each mounting two 50-caliber machine guns. In addition, it has four similar fixed waist guns and can be fitted with one extra belly gun, giving it thirteen in all. The Navy uses the same bomber under the designation PBY4. Stripped of its armament and modified internally, the bomber becomes a transport—the Army's C-87, which is also known as the Liberator Express. It can carry a 6-ton load more than 3000 miles at 300 miles an hour. The first C-87 was produced at Fort Worth in August, 1942, and was flown around the world by Maj. Richard T. Kight, with Wendell Willkie as a passenger. Another C-87 flew from Brisbane, Australia, to Washington, D. C., in 44 hours. The Liberator was





FINAL ASSEMBLY LINE

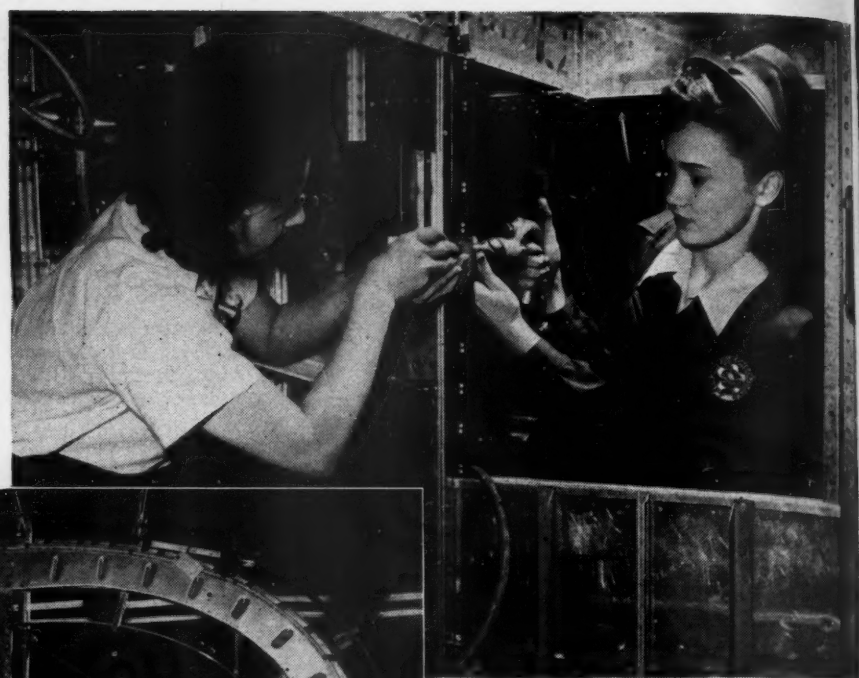
Borne on carriages tied together with tow bars and provided with platforms so that workers can easily reach the various plane parts, B-24 Liberator bombers and C-87 Liberator transports move down a double assembly line, below, and emerge through a huge door at the end of the building to be flight tested. Alternating on the first line with the gleaming, unpainted B-24's are camouflaged units designed for use by the RAF. The line in the background is made up of transports. Space is conserved by placing the planes at an angle of 45°.

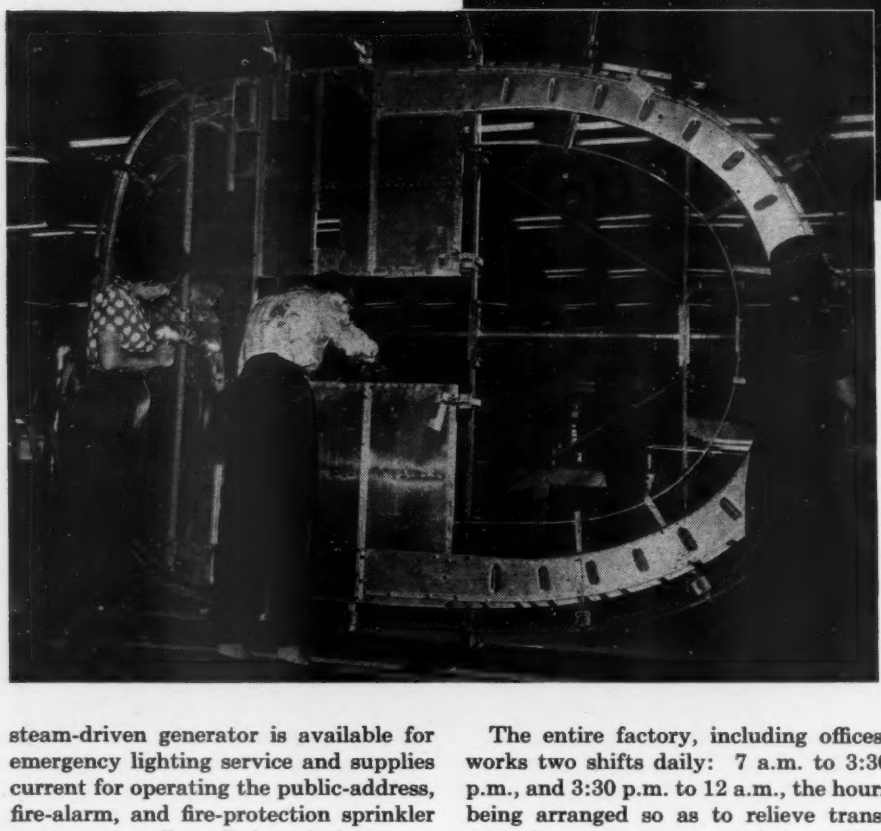
designed by I. M. Laddon, a former vice-president of the Consolidated Aircraft Corporation, as the concern was known prior to its merger with Vultee in March, 1943.

The factory at Fort Worth, which was planned and built by The Austin Company, is almost of as much interest as the planes that are put together in it. There are nine buildings, one of them nearly a mile long. All are windowless, artificially lighted and air conditioned, and the brick outer walls are insulated with 2½ inches of fiber glass. All manufacturing operations are carried on under one roof. A score of overhead monorail cranes, with cabs nearly 50 feet above the floor, supplement trucks in transferring loads about the plant. The cranes that travel this "upside-down" rail system are moved by the turning of a pneumatic-tired wheel that bears against the underside of the rail.

Twelve refrigeration units of 11,550 tons total capacity supply chilled water at 47 to 50°F. to cool the buildings during warm weather. The system uses 14,000 gpm., enough to supply Fort Worth. This and the water required for other purposes in the plant is pumped from nearby Lake Worth. When the outside temperature falls to 62°, an indicator on a central control board flips from the word "summer" to "winter." Then the operator has only to turn a few knobs to send heated instead of chilled water through the system. In either case, the water is circulated through radiation units in fan decks located on elevated platforms from which each 12-foot fan sends 40,000 cfm. of conditioned air out into the working spaces. There are 36 of these fan decks in the assembly building and parts plant and some of them are as large as a 6-room house. The system includes 15 miles of air ducts and 81 miles of temperature-control wires.

Power is purchased from the Texas Electric Service Company and is delivered over a 60,000-volt transmission line to two substations, where it is reduced to 4160 volts and distributed through underground conduits. Transformers in the buildings step down some of the current to 110/208 volts. There are approximately 2500 motors in the plant for driving machine tools. The fluorescent-lighting system numbers some 60,000 tubes, and the monthly cost of replacements runs to around $20,000. More than 500 floodlights, ranging from 300 to 1500 watts each, illuminate the walkways, streets, and parking areas adjacent to the buildings. The entire factory can be blacked out by throwing a single switch. A 6¼-kva.





WOMEN WORKERS

Forty percent of the employees are women, and many of them do the type of work shown here. At the bottom they are drilling rivet holes and performing other preliminary tasks on a bulkhead in the fuselage subassembly department. The top picture shows a riveter and her "bucker-up" working inside a C-87 transport.

steam-driven generator is available for emergency lighting service and supplies current for operating the public-address, fire-alarm, and fire-protection sprinkler systems, as well as all time clocks.

The plant is so extensive that gasoline-engine-driven scooter cars are provided for executives and supervisors so they can get around quickly. Mail carriers and messengers use bicycles. The dial-telephone system is large enough to serve a fair-sized city, and all wiring is underground. As a further means of communication there is a pneumatic-tube system with 12 miles of tubing and 40 stations. The cafeteria can seat 900 persons and is patronized chiefly by the office force. More than twenty wagons dispense food in the various shop departments during meal hours. Many workers buy soup, drinks, or dessert to supplement their own lunches, but they can obtain a full meal if they want it. Paper cups, plates, and utensils are used because they can be disposed of in trash cans and obviate the need of gathering up and washing dishes.

The entire factory, including offices, works two shifts daily: 7 a.m. to 3:30 p.m., and 3:30 p.m. to 12 a.m., the hours being arranged so as to relieve transportation congestion as much as possible. Large trailers, with longitudinal seats, travel between Fort Worth and the plant at the time of shift changes. The shop force on the second shift is about half as large as that on the first shift, while the night office force is only about one-tenth the size of the day force. All departments—offices and shops—observe a 10-minute rest period twice during each shift. Approximately 40 percent of the employees are women.

Construction of the factory was started in March, 1942, under a $12,000,000 contract. Originally, it was intended to be strictly an assembly plant, with the parts coming from another builder of Liberators. However, work progressed so rapidly that it was evident that the factory would be completed sooner than the one which was to furnish the parts. Accordingly, a $14,000,000 parts building, which covers an area equivalent to ten city blocks, was added to the construction program months before the assembly plant was ready for occupancy. Parts for the first B-24 bombers were obtained from the Consolidated factory at Los Angeles, Calif., thus enabling the Fort Worth establishment to put its first plane in the air just a year from the date ground was broken and 100 days ahead of schedule. It was given its test flight by George J. Newman, manager of the Fort Worth Division. At 37, Mr. Newman is a veteran of 21 years experience that has covered every branch of the aviation industry. He is one of three employees who have been with Consolidated since Maj. Reuben H. Fleet founded it in Greenwich, R. I., in 1923 to produce trainer planes. In the course of his well-rounded training he served for a while as test pilot and holds the highest pilot's rating obtainable.

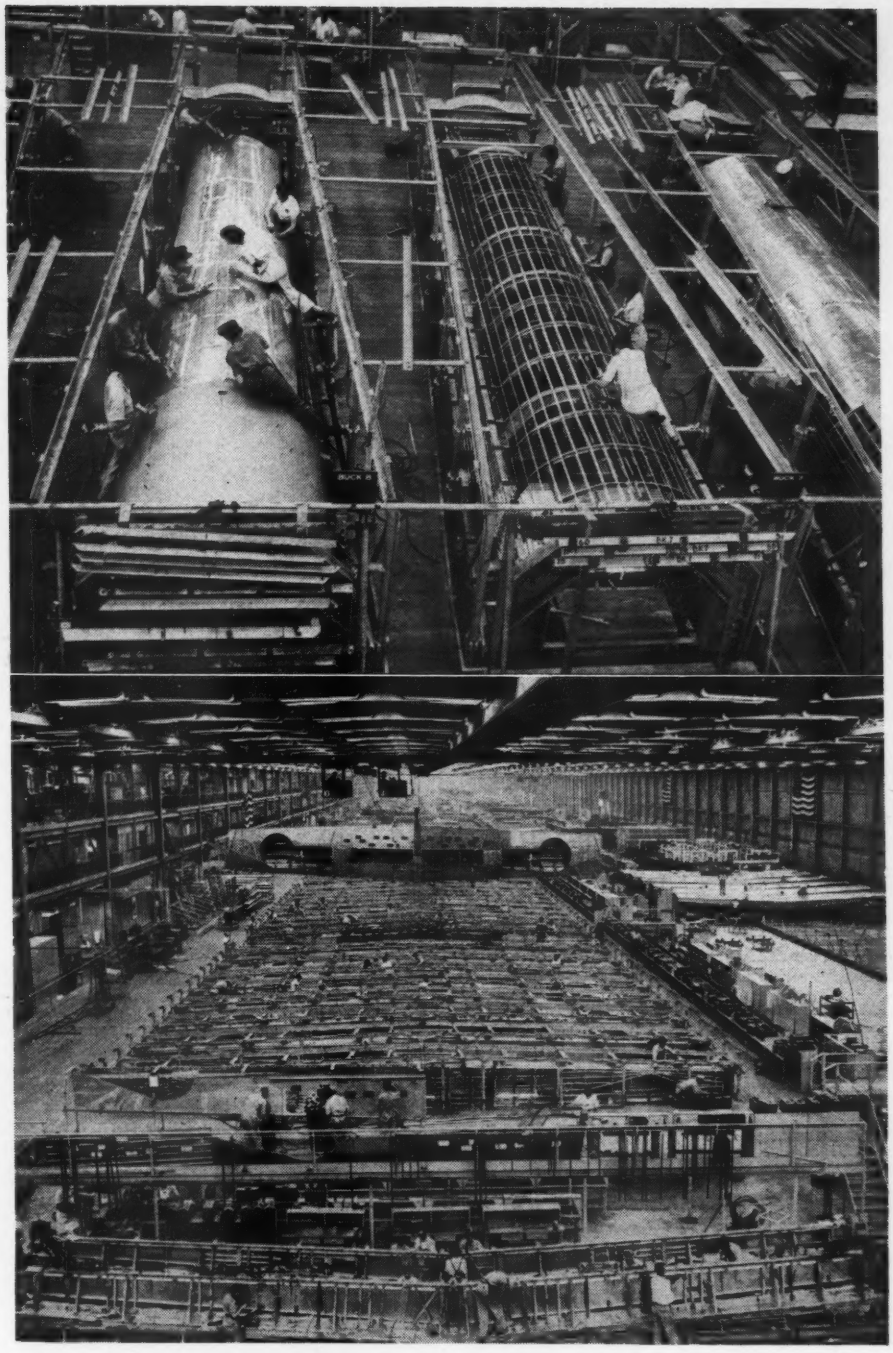
For a time after the Fort Worth plant got underway it functioned as a modification center where planes already in service were changed and modernized. That assignment was shifted to another factory, however, and since then all facilities have been devoted to the making of new bombers and transports which move down the double assembly line side by side. A bomber of the size of a Liberator is, of course, a complicated and delicately balanced machine that must be put together with the utmost care and precision. It follows that its building is no small task, even with the highly organized factory routine and the intelligent application of mechanical equipment that American engineering management and ingenuity have devised.

A B-24 is made up of 92,272 parts, every one of which serves a definite purpose and must be made with accuracy

and put in its allotted place securely and correctly. The craft is held together by 400,000 aluminum-alloy rivets, each of which must be separately driven, and also contains 85,500 nuts, bolts, and screws. The operating and communication systems call for the stringing of 34,700 feet of electrical wire, for the making of 3627 electrical and plumbing connections, and for the laying of 4200 feet of hydraulic, air, gas, and oil lines. Then, of course, there is the work of installing all the equipment, including engine assemblies, armament, operating and radio instruments, wing deicers, and hundreds of other items. Each and every one of these must be designed for its express purpose and manufactured to exact specifications, and then all have to be brought together simultaneously for assembly into a complete structure. The accomplishment of all this with such speed and accuracy as to permit turning out planes faster than was dreamed possible but a few years ago constitutes the modern industrial miracle that we call volume production.

A hint of the progress Consolidated-Vultee has made in developing this highly ramified system of building Liberators on a wholesale scale was contained in a recent advertisement signed by Tom M. Girdler, chairman of the board of directors, and headed, "Tom Girdler Reports to the American People." It revealed that the same amount of direct labor that produced one Liberator three years ago now produces fourteen! The monthly output per employee rose from 47 pounds in December, 1941, to 151 pounds in December, 1943. These figures refer to the San Diego plant of the company, pioneer builder of Liberators, but it can be safely assumed that proportionate advances have been made in the newer Fort Worth establishment. This increase in production per employee has naturally reduced costs, which means that the United Nations now get their Liberators for less than they formerly paid for them. On February 16, 1944, Brig. Gen. Albert T. Browning, director of the Purchases Division of the Army Service Forces, announced that a contract had been let for 4500 at $137,000 each, as compared with $238,000 under the previous contract.

The basic idea behind the volume production of Liberators at Fort Worth is to reduce to a minimum the number of operations on the final assembly line. In other words, subassemblies are built up as far as practicable, and these are brought together to form the finished plane. Accordingly, the final line is fed by various subassembly lines which, in turn, are fed with parts from the respective processing departments or from outside suppliers, as the case may be. The entire manufacturing program is based on a flow of materials so coördinated that each component part reaches its point of application at the exact time it is needed. Unless this schedule is maintained in every section of the plant the output of planes will slow down.

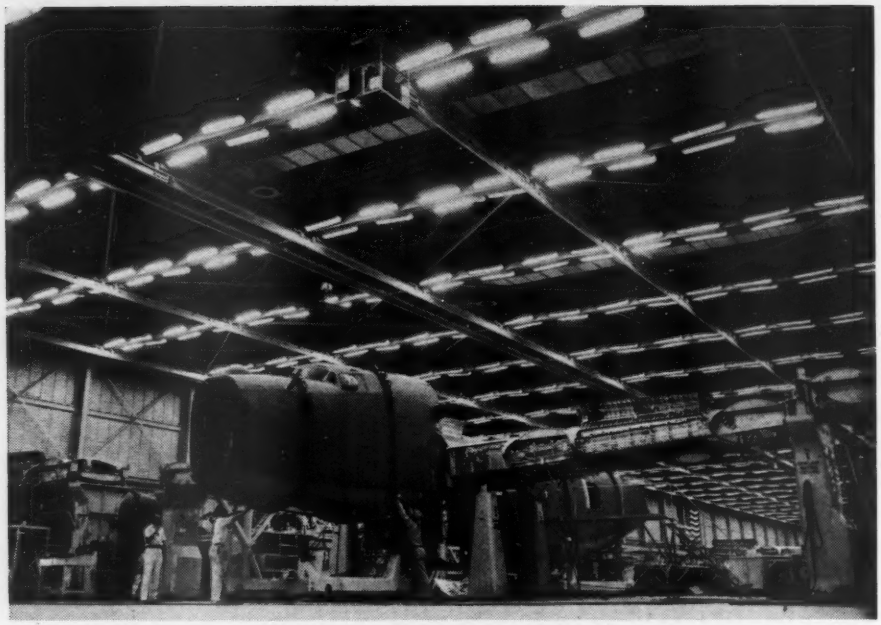


STRUCTURAL BUCKS

Individual members of the fuselage nose, fuselage tail, and wing center sections are made up on the mezzanine floor and are then fabricated in metal fixtures or bucks on the main floor. At the top are fuselage-tail bucks. The workers pass from one to another in performing their respective operations, whereas on the final assembly line the planes move past the stations at which the materials and workers are located. At the bottom are pictured some of the wing bucks. In the background is shown a crane lifting a wing center section from a fixture.

As explained by Division Manager Newman in an article in *Aviation*, the plant was laid out with the aim of substituting work time for travel time. By moving the work directly from one operation to the next, much dead time is eliminated. Wherever possible, workers' benches are arranged so that parts can be handed from one to another as they undergo processing in building them up for assembly into larger units or into completed planes.

Materials flow is the industry's term for this whole subject of routing, and covers it very aptly. It has been so far developed at Fort Worth that the travel of a piece of aluminum from raw stock to the finished part is about 1 mile, as contrasted with 10 to 12 miles in some prewar aircraft plants. In general, raw



MATING FIXTURE

A fuselage nose is being lowered into the aligning fixture where it is mated with the fuselage tail and the wing center section, forming the nucleus of the plane. The unit is then transferred to a carriage to begin its trip down the final assembly line.

stock enters one end of the factory and follows a more or less direct path until it emerges at the other end as part of a plane. More specifically, it may be stored for a time, then move across the plant while undergoing the various processing steps, and join the completed-parts stock adjacent to its assembly station where it halts again in storage until it is needed. Then it travels forward steadily and quickly until its journey is completed.

Aluminum sheet comes into the factory over one of three depressed railroad tracks in the parts building and is distributed to storage spaces adjacent to the different fabricating departments—drawbench, sheet-metal, tube-bending, welding, machine shop, etc. There it is placed in racks near cutting shears to be drawn upon as needed. After being cut to size, the material is heat-treated and anodized and then passed through the successive part-making operations. Finished parts go to the respective subassembly lines. Approximately 20 percent of the parts—including engines, wing flaps, bomb-bay doors, rear turret, landing gear, ailerons, elevator fins, and stabilizers—are obtained from other manufacturers under contracts and are stored and routed to the assembly lines as they are required.

The three major subassemblies are the wing center section, the fuselage nose section, and the fuselage tail section. As is the case with most subassemblies, these are made up in stationary fixtures and the workers go from one to another to perform their particular operations. On the final assembly line this procedure is reversed—the line moves past the stations where the workers and the materials are located and at each one the craft has something added to it. When it reaches the end of the line the plane needs only to be tested before being turned over to the Government.

The assembly line starts when the wing center and fuselage nose and tail sections are picked up by overhead crane and lowered into a mating fixture, where they are held together by straps until they can be more securely joined. The unit is then lifted from the fixture and deposited on a carriage to begin its trip down the line. The carriages are supported on small wheels that run on rails laid flush with the floor so that trucks can easily run across them. Each is fastened to the one in front of it by a tow bar, and the entire line is drawn by a motorized winch at its head. Movement is so slow as to be imperceptible. The planes are placed on the carriages at an angle of 45° to the line of travel, and so positioned four of them occupy no more space than would three if pointed head on. Near the discharge end of the line the telescoping tow bars are let out to increase the distance between planes from 50 to 65 feet in order to give more working room.

Attached to each carriage is scaffolding from which the workers can reach every part of the plane, and compressed-air and electrical outlets are provided so that connections can be made for operating drills, riveting hammers, and other tools. The carriages are painted white to reflect light and to promote cleanliness. One advantage of their use is that the line keeps moving regardless of any shortage of landing gear. They also make it possible to test the hydraulic mechanism of the retractable landing gear and the landing flaps, etc., without jacking up the planes.

In general, the first half of the line's travel is devoted to completing the work on the wing center section and the fuselage. This involves a great amount of detailed fitting to coördinate the sections and the installation of many small parts that cannot be incorporated earlier. These parts are located in racks at one side of the line. During the second half of the travel are added the major units that are required to finish the plane. The outer sections of the wings are moved in from the sides on self-leveling and self-aligning fixtures. Then comes the tail assembly, which needs only four connecting bolts to hold it in place; the four engines are installed; and the armament, including the turrets, is brought up for placement from nearby assembly areas. The four propellers can be hung in six minutes. The most difficult job is that of lowering the top turret into position because only 1/16-inch clearance is provided. The bombardier's glass enclosure at the nose is left off until last to facilitate passage of workers in and out of the fuselage.

But, as has already been pointed out, the assembly line will bog down unless all the contributing operations are carried out on schedule. Back through the subassembly lines, the parts department, and the various subsidiary sections where preliminary processing is done, everything must function according to plan if aircraft production is to be maintained. Most of the aluminum parts from which the planes are fabricated are formed in the drawbench, drop-hammer, and hydropress departments. Four-fifths of the members that give a machine its structural shape are produced in the drawbench department where strips of metal are fed into rollers that bend them into sections ranging in form from a simple L to one resembling an end view of a derby hat with a crease in the center. These are the stringers, bulkhead components, shaping braces for wing leading edges, etc. Some of the shaping is done by a "wiping" process by which one end of a metal strip is held by clamps while a pneumatic plunger pushes a shoe against the strip and, with a wiping motion, bends it around a form that will give it the desired shape. Following forming, the members are hardened by heating them to 900°F. in a salt bath and then quenching them in cold water. This treatment causes the metal to buckle, necessitating straightening by means of hydraulic stretchers. The drawbench department also makes from wire all the rivets that are used.

Complicated metal sections are shaped in a hydropress in which the descending platen, faced with a blanket of rubber 4 feet square and 8 inches thick, presses the sheet of metal into the recesses of a

die. Irregular contours are formed by air-operated drop hammers, there being thirteen Chambersburg Cecostamps in the department. A pattern of the finished member is first made in plaster. This is transferred to a sand mold into which firksite metal is poured to make the lower hammer die. The upper die is cast of lead. Electrically operated Yoder hammers are also used to forge curved sections. After the metal parts are shaped they are trimmed with saws and then go to the drill press and burr bench for finishing operations.

Aside from the departments that form and otherwise prepare the structural members, there are others that perform necessary preliminary operations on other essential materials. There is, for instance, the electrical bench department which makes up the 6 miles of current-carrying wire that is in each bomber. The pieces range in length from 4 inches to 28 feet; some are single strands and others are harnesses as thick as a man's wrist. The autosyn trunk line that leads to the engines and to the instruments on the flight deck is composed of four groups of wires each having 28 strands and eighteen plugs. To each of the latter are attached from 18 to 24 wires.

To cite another example, there is the upholstery department which makes cushions, pads, soundproofing and insulating material, fabric envelopes for

LOFTING

Full-sized engineering drawings of plane parts are penciled on rolled steel sheets. The drawings are photographed, and from transparencies of the pictures are produced blueprints to guide the shops in the work of construction and fabrication. Meanwhile, the master sheets go to X-ray rooms where the designs on them may be duplicated in their entirety, to aid in assembling fixtures for the manufacturing departments, or in part for use in the tool-making department. Before the drawings are made, a special lacquer is applied to the metal sheets to render them luminous to X-rays. After that they are carefully sanded to remove any rough spots that might deflect the pencils of the draftsmen. Some of the sheets measure 7x14 feet, and a number of them may be placed together to obtain lengths up to 90 or 100 feet. The procedure is called lofting because shipbuilders similarly work in lofts in laying out their vessels. The picture shows a small part of the Consolidated-Vultee loft, with young men and women, most of them recent college graduates, doing the designing.

LIBERATOR EXPRESS

A C-87 transport plane being loaded with freight through its 6-foot-square door. The C-87 is the B-24 bomber minus armament and with certain structural changes, mostly in the fuselage tail, to strengthen it for carrying heavy loads. There are seven windows on each side and removable seats that are used when the plane is transporting troops.

covering the control surfaces, and boots for the engines, oleo struts, etc. By means of an electric knife, inch-high piles of cloth are cut along lines drawn with the aid of a template, and 40 sewing machines are kept busy doing the stitching. The kapok filling of pads and cushions is blown in with compressed air.

These and other departments all contribute to the subassemblies and to the final assembly. Many of the subassembly operations are conducted on a mezzanine in the parts department. Even such large units as the fuselage nose and tail and the wing center section have their beginning there, but the final work on them is done on the main floor in specially designed metal fixtures or bucks. There much of the riveting is done, the bucks being arranged so that work can be carried on at two levels. Actually, the workers swarm all over them, as accompanying pictures show. Each buck has an air-distribution system made up of reclaimed oil-well pipe and having numerous take-offs for individual hose lines leading to the tools.

Rivets are of several types and range in diameter from 3/32 to 3/8 inch. Standard aluminum-alloy rivets for airplane construction are designated as A17S-T, 17S-T, and 24S-T, all of which are produced with heads of several types. Joints requiring much strength are made

COLD ROOM

In order that plane parts may be tested at temperatures that prevail in the stratosphere, the laboratory contains a cold room that is insulated with 14 inches of cork. Low temperatures are obtained by immersing dry ice in methanol and circulating the latter through refrigeration plates. A ton of dry ice is required to drop the temperature to –100°F. The picture shows a laboratory employee testing some hydraulic equipment in subzero surroundings.

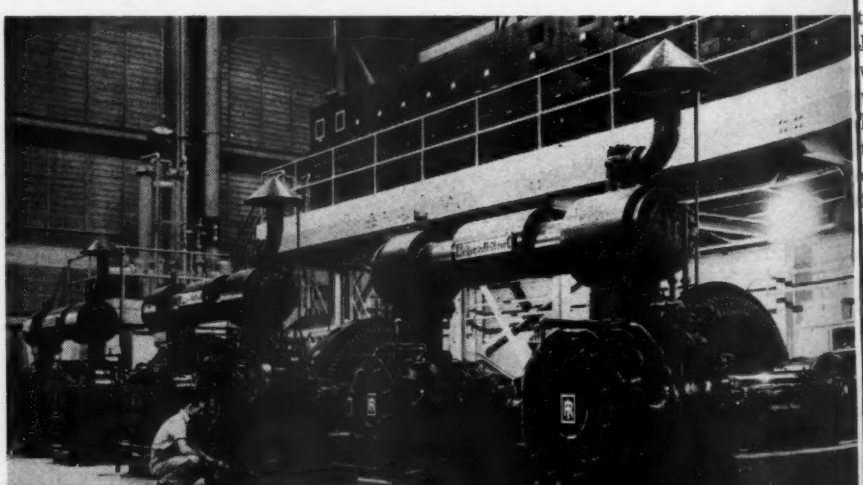
with 17S-T or 24S-T rivets. All are driven while cold, but as they harden at room temperature they must first be softened by heating them to around 930°F. and quenching them in cold water. When so treated, it is necessary, in the case of the 17S-T and the 24S-T, to retard the aging or hardening process until they are driven. This is accomplished by storing them in a refrigerated space, and they are consequently known as icebox rivets. In the Fort Worth plant the refrigerated rivets are distributed in cellophane bags, each of which contains a dozen of the same size.

All riveting in the bucks is done with pneumatic hammers of a type that has been developed in recent years expressly for the airplane industry. They are small and light so that they can be easily handled by women. Approximately 3000 of them are in use, in addition to about 2000 air-operated rivet squeezers and 3000 air motors and miscellaneous pneumatic tools such as drills, grinders, etc. Compressed air for these and for other services is supplied by seven Ingersoll-Rand 2-stage compressors each driven by a 300-hp. synchronous motor. Three of them are grouped in the boiler-room section and the four others are in the parts department. The discharge from all the units feeds into one distribution system. The main line consists of 12-inch welded pipe which runs almost the full length of the assembly building and continues on into the parts building. It is carried overhead and has expansion loops every 500 feet. Branch lines extend from it to the various locations where compressed air is used.

At every stage of the manufacturing process, from raw material to finished aircraft, inspectors are on the job. Their reports are all filed, and the record for any plane is available for checking i case trouble develops during testin or later. The inspection departme holds an A rating, the highest grant by the Army Air Forces.

When a machine comes off the as sembly line it is turned over to the yar and flight department for final inspec tion and testing. Expert mechanics g over it from nose to tail to make certain that every structural detail is as it should be. Then the wheels are lowered air is pumped into the oleo struts of th landing gear, and the plane lifts itself of the carriage. A door 200 feet wide an 40 feet high at the end of the building i raised by motors, and the ship, drawn by a tractor and aided by the slightly slop ing concrete floor, rolls out. There, on a great expanse of concrete paving, it is supplied with gasoline and oil, and the engines are run. Every instrument and every circuit and line are inspected.

Then comes the final test, the "shake-down" flight, during which the plane is flown to a height of 35,000 feet and put through every maneuver that it is likely to perform in actual service. In the case of bombers, all guns are given a firing test. Flight testing costs about $1000 an hour. If any defects are found, they are remedied, and the machine is again sent up. After it has been passed upon as ready for service it is filled with gas and oil and sealed so that no one can enter it or tamper with it. An armed guard watches over the plane until a crew from the Army Ferry Command flies it away to take its place in the great air armada that is writing history in the flaming skies of war.

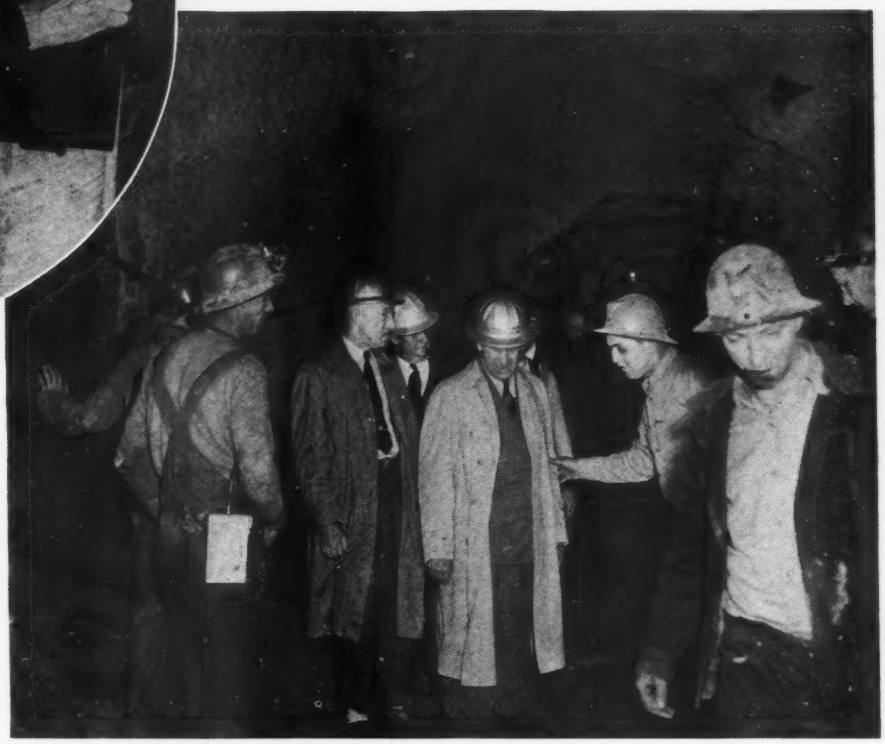


SOURCE OF COMPRESSED AIR

In addition to driving approximately 7000 pneumatic tools, compressed air also performs various other services in the factory. The compressor plant consists of seven identical Ingersoll-Rand machines having a combined output of 10,500 cfm. Three of them are shown here; the four others are at a different location. Each compressor is driven by a General Electric 300-hp. synchronous motor. The air is discharged at 105 pounds pressure and passes through aftercoolers to extract water vapor before going into the 12-inch overhead pipe line that delivers it throughout the assembly building and the parts plant.

Thirteen-Mile Tunnel Holed Through

Allen S. Park



THE FINAL SHOT

At the left, S. O. Harper, chief engineer of the U. S. Bureau of Reclamation, is seen throwing the switch that detonated the last blast. The other picture shows the tunnel after it had been holed through. The men in the background are standing on the muck pile. Ray Blasongame (with outstretched arm), superintendent of the west-heading operations in recent months, is talking to three members of the official visiting party. The middle one of the group is Porter J. Preston who was retired by the Bureau of Reclamation while serving as supervising engineer ot the project of which the tunnel is a part.

THE longest tunnel ever driven from only two points of access was holed through on June 10 underneath the Continental Divide in Colorado. It is the 13-mile Alva B. Adams bore that will carry water from the western slope of the range to the eastern side to furnish supplemental irrigation for 615,000 acres of rich farming land in northeastern Colorado. It is a part of the U. S. Bureau of Reclamation's $50,000,000 Colorado-Big Thompson Project and is named for a former United States Senator from Colorado who aided in initiating the latter. The tunnel has been under construction since June, 1940, but the actual working time was approximately three years. Previously, the 12½-mile Simplon Tunnel in Italy, one of the early railroad bores through the Alps, was the longest one excavated from only two headings. The San Jacinto Tunnel of the Colorado River Aqueduct is 13 miles long, but work on it was conducted from several intermediate points, as well as from the ends. The same is true of the 20-mile New York City water tunnel that distributes water to various parts of the city. The longest of all tunnels is New York City's new Delaware River Aqueduct that extends for a distance of some 80 miles. It was constructed in sections of a few miles each by opening headings both ways from the bottoms of shafts.

The final blast in the Alva B. Adams Tunnel was fired at a point approximately 8 miles in from the east portal and 5 miles from the west portal. For a number of days before holing through, each of the crews advancing toward the meeting point had heard the other drilling and shooting. On the morning of June 7, with 121 feet of rock intervening, drilling was discontinued in the west heading for reasons of safety, and the east-side forces completed the work, except for three 33-foot pilot holes that were drilled through the granitic plug from the west side on the morning of June 9. Telephone wires were run through one of the holes to establish direct communication. By the following morning only 8 feet of rock remained, and this was being drilled and loaded as a party of officials and guests started in from the east portal on trains provided at that end by the contractor, S. S. Magoffin Company, Inc.

The arrangements for the ceremonies were in charge of J. M. Dille, secretary-manager of the Northern Colorado Water Conservancy District that is composed of farmers who will reap the benefits of the additional water the tunnel will bring them and whose payments for it of $2 an acre-foot will, in the course of 40 years, repay the Government a sum not exceeding $25,000,000. The balance of the project's cost will be charged to power development and will eventually be returned to the Government through the sale of current. Among the guests were Oscar W. Chapman, assistant secretary of the Department of the Interior, of which the Bureau of Reclamation is a part; Porter J. Preston, who was retired upon reaching the age limit while serving as supervising engineer of the project; and Platt Rogers, head of the contracting firm that drove the first 6600 feet of the western end of the bore. The party was greeted at the east portal by Sam Magoffin and his son John and by Frank R. Purvis, vice-president of the Magoffin company and superintendent in charge of tunnel driving on the east end.

The trains halted about 1000 feet back from the heading, and after a radio

OUT OF THE PORTAL

The first group to pass through the tunnel is pictured emerging from the west portal. Riding on the front of the locomotive is Lou Stiers of Stiers Bros. Construction Company, contractor on the west end.

broadcast S. O. Harper, chief engineer of the Bureau of Reclamation, closed a switch to set off the final multiple blast controlled by 0- to 10-delay electric detonators. The shot left a pile of muck about one-third the height of the tunnel. Blower lines extending from both portals began to draw out the acrid powder fumes while the party waited for the atmosphere to clear. Some of the more venturesome tunnel workers scrambled over the pile as soon as they could reach it. The first one across was "Chief" Brewer, a full-breed-Indian shift boss on the west end who has worked in tunnels all his adult life. He returned accompanied by several of the east-heading crew, whose principal interest seemed to be that of examining the equipment on the west side and of asking questions regarding the procedure that had been followed there. Although the two forces had actually been separated for several months by less than a mile of rock, the trip by highway between the portals involves a drive of more than 100 miles across the towering mountains, and few of those employed on one side had ever visited the other.

As soon as the ventilating systems had restored normal conditions, those who had come in from both portals converged upon the muck pile to see the effects of the final blast and to look across a space that had been closed by solid rock only a few minutes earlier and for eons before. One of the first concerns of tunnel drivers is to observe how closely the two sections meet when they hole through. So far as the eye could judge, the juncture in this case was well-nigh perfect. Pending a check-up, Bureau of Reclamation engineers, who had been projecting the line progressively through the bore from backsights established at both ends of a 15-mile straight line run across the range before tunneling was started, expressed confidence that the two converging sections would coincide within 3 inches.

Upon crossing the muck pile, the members of the official party were greeted by Lou Stiers of the firm of Stiers Bros. Construction Company which had driven all the western end of the tunnel except the first 6600 feet; by Ray Blasongame, tunnel superintendent there in recent months; and by Bureau of Reclamation engineers stationed at the west portal. John R. Austin, manager of the contractor's operations and veteran tunnel driver, was unwillingly absent, being confined to a hospital room in Denver, recovering from pneumonia. The party boarded man cars and rode to the west end of the bore on the eastern shore of Grand Lake, largest natural body of water in Colorado. After more broadcasting, the official group and other guests appeased the inner man at a dinner tendered by the Stiers company. No women were permitted in the tunnel, ostensibly because of an old superstition among miners that evil will befall any underground work on which members of the distaff side set foot. There may once have been such a superstition, but it has been defied on occasions in recent years without dire results. John R. Austin welcomed women visitors when he was driving the Carlton Tunnel at Cripple Creek, Colo., and set a new record despite their presence.

At the dinner, Mr. Harper complimented both contractors upon their work and thanked them for their coöperation with the Bureau of Reclamation. He

mpared the safety record on this job th that on the 6-mile Gunnison Tun-l, also in Colorado and the first im-rtant tunnel ever driven by the Bureau Reclamation. On the earlier work, hich was conducted between 1904 and 09, there were sixteen fatalities, where-only one man lost his life in the Alva Adams Tunnel. He was unconscious hen found, and the cause of his injury as never determined. More than 500,-00 pounds of dynamite was used with-t an accident attributable to blasting. Mr. Harper also called attention to the reat advance in tunneling machinery nd methods which makes possible to-ay's speed in boring through rock. Only few years ago, he said, this 13-mile unnel would have been a 10-years' job.

It was the original intention of the Bureau of Reclamation to let a single ontract for the driving of the tunnel. ids on that basis were opened twice, nd the single firm bid received exceeded 18,000,000. Contractors evidently re-embered the experience of Hitchcock Tinkler with the Moffat Tunnel, a -mile railroad bore that, in the 1920's, erced the Rockies about 25 miles south f the one just completed. The engi-eers' estimate of the cost of that job was 6,800,000, and bonds of that amount ere voted to pay for it. Geologists gave ssurance that the rock to be penetrated ould be generally sound and stable, but he contractor encountered sections here 12x12 timbers buckled under the remendous overhead pressure and where he floor heaved badly. In some places hey had to stand heavy steel sets as lose together as they could get them to old up the roof. The final cost was round $18,000,000, and the work took r more than the expected time. The ontracting firm had fortunately taken he job on a cost-plus basis.

In view of what was found then, it was nly natural that there should be fore-odings about the solidity of the earth's ards where the new bore was to enetrate them. But the Bureau of Rec-lamation thought the contractors were overly pessimistic, so it rejected all bids and then adopted a plan of constructing the tunnel piecemeal. It asked for bids on driving 8000 feet at the east end and 6600 feet at the west end. These sections were awarded to the respective low bidders—S. S. Magoffin Company, Inc., on the east end, and Platt Rogers, Inc., on the west end. The Magoffin firm, starting work on June 23, 1940, finished its 8000 feet in 73.5 percent of the allotted time and received another contract for an additional 7000 feet. By the time that was completed we were at war, and the company was directed to continue under a work order. A second work order was issued later, and when that terminated, construction was finished on force account.

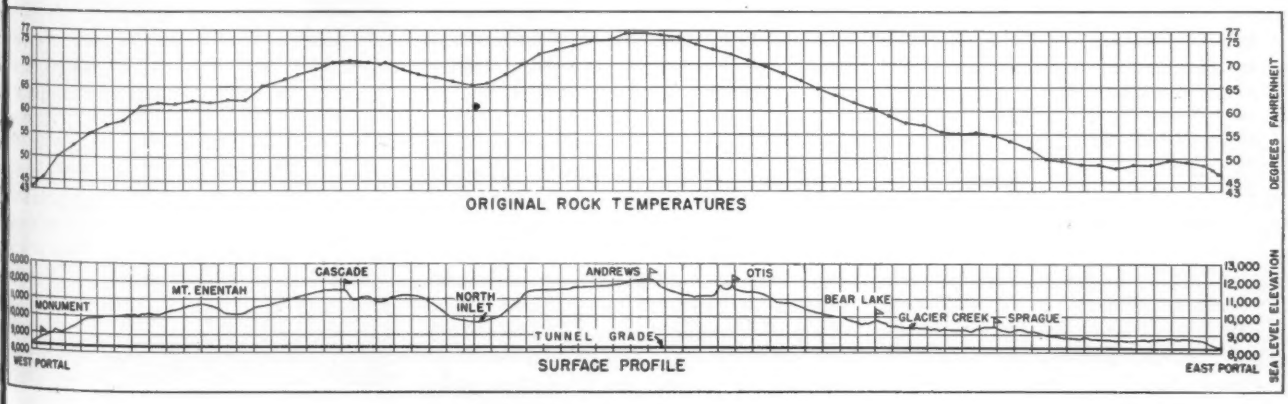
When bids were asked for a second section on the west side, Stiers Bros. Construction Company submitted the lowest figure and took up the job where Platt Rogers, Inc., left off. Upon completing its contract, it was given a work order to continue. On December 31, 1942, the Government shut down operations with 55,500 feet of tunnel excavated. Work was resumed on the west end on August 24, 1943, and on the east side on September 17.

Contrary to the contractors' worst fears, no conditions comparable to those in the Moffat Tunnel were met. No supports heavier than 6-inch H-beams on 4- to 5-foot centers were required, and in many places where the rock would not stand by itself guniting sufficed to hold it firmly. All told, 26,300.3 feet of the bore was supported with steel sets—19,347 feet on the east end and 6,953.3 feet on the west side, where guniting was practiced to a greater extent. There was no heaving of the floor other than in a short section on the west side, and this occurred during one of the several shutdowns. The rock was predominantly granite and schist, and the best conditions were found under the highest part of the range where the rock cover, and hence the pressure, was greatest. The cost of the tunnel, under the course adopted, was approximately $6,800,000, or around $100 a linear foot, according to Mr. Harper, who pointed out that this is more than $11,000,000 less than the rejected bid price for the entire job.

The tunnel, as excavated, is horseshoe-shaped in section and has a width and height of 11 feet 9 inches in unsupported ground and 12 feet 9 inches where steel sets had to be placed. Approximately 300,000 cubic yards of rock, measured in place, was removed. As the bore will be lined with concrete to produce a finished circular section 9 feet 9 inches in diameter, the contractors were penalized $15 a cubic yard for overbreak outside the designated pay lines. This provision necessitated accurate drilling and shooting to hold excess excavation to a minimum.

Except for the first 6600 feet at the west end, the tunnel was driven entirely with Ingersoll-Rand DA-35 power-feed drifter drills. Each contractor used five of them mounted on a structural steel drill carriage or jumbo. In both cases, the original drills were still in service when the work was completed, and no drill was discarded. The Magoffin firm had twelve drills available for driving more than 8 miles of tunnel, while the Stiers company had a total of sixteen, some of which were transferred from the Treasury Tunnel at Ouray, Colo., when the firm completed its operations there last spring. These reserves furnished replacements whenever machines were taken off the carriages for cleaning or overhauling. Both contractors practiced rigid maintenance of drills and other equipment.

The two contractors also utilized Ingersoll-Rand Jackbits throughout. New starter bits were 1⅞ inches in diameter and were reduced 1/16 inch in gauge at each resharpening. Bits were changed every 2 feet, the succession of Jackrods used in each hole being 3, 5, 7, and 9 feet long. Holes were started with bits of



TUNNEL TEMPERATURES

Bureau of Reclamation engineers drilled 6- to 10-foot holes in the tunnel walls every 1000 feet, filled them with water, and took temperatures after a stabilization period. The readings at all these points were plotted, as shown at the top. It was found that the temperature gradient assumed a curve that conformed very closely to the surface profile. The temperatures ranged from a minimum of 43° to nearly 77°F.

FRANK R. PURVIS
Vice-president of S. S. Magoffin Company, Inc., and superintendent in charge of driving more than 8 miles of the tunnel from the east end.

either 1⅞- or 1 3/16-inch diameter, and reductions in gauge for the three changes were either 1/16 inch or ⅛ inch, depending upon the type of rock. Bits were reconditioned by hot milling with Ingersoll-Rand equipment. Each contractor had a JMA hotmill and two Jackfurnaces for resharpening bits. Another furnace and an I-R sharpener were employed at each end for shanking Jackrods, which were rethreaded in lathes. Up to seven uses were obtained from a bit by resharpening. On the east end, approximately 122,000 bits were used to drive 43,004 feet of tunnel and to remove 195,000 cubic yards of rock. This is an average of 2.83 bits per linear foot of advance, or 1.6 cubic yards of excavation per bit.

Ingersoll-Rand compressors supplied compressed air at both portals. At the east end the discharge pressure ranged from 115 pounds at the beginning to 125 pounds when the heading had been advanced its greatest distance. At the west end the pressure at the compressors was 125 pounds at all times. Air was conveyed into the workings through 6-inch lines.

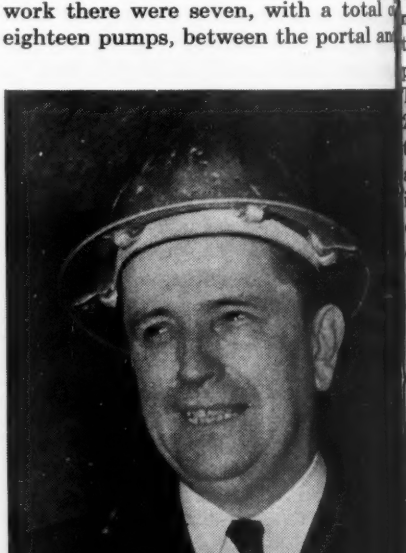
Both contractors used Eimco-Finlay No. 21 air-powered loaders at the headings. Muck was hauled in 91-cubic-foot Granby-type cars having removable dumping arms that were attached when the trains reached the dumps. Within the tunnel, trains were drawn by storage-battery locomotives, while gasoline- and diesel-powered units served outside. Inside the bore, trains were controlled on the east end by an electric-eye block system, the blocks being 6200 feet long. When a train entered a block the lights were shifted from green to red, but the electric eye was adjusted so that the lights would not change when a man walked through the beam. Trains were handled by a telephone dispatching system on the west end.

On the east side, ventilation was provided by a series of four 100-hp. reversible blowers rated at 9000 cfm. each. One was stationed outside the portal and the three others were spaced at intervals within the tunnel. Air was exhausted from the heading for 45 minutes following a blast, and during the remainder of the time balance was maintained between suction and blowing to keep the bore clear of fog. A system of clocks and electrical relays automatically controlled the reversing of the blowers so that each one changed over in order and at the proper time in relation to the others. A single 20-inch pipe line conveyed the air. When the heading was in 8 miles, it was possible to deliver to it 7000 cfm. of air. Blowers of 12,000 cfm. capacity and two 20-inch lines were employed on the west side. As a result, only one booster unit was required, this being stationed 21,300 feet from the portal during the final stages of the work.

In addition to the record set for the longest tunnel ever excavated from two faces, the Magoffin forces established a new mark for the greatest advance at one heading by driving 12,000 feet farther than the previous record of 31,000 feet that was made in the Carlton Tunnel. Because of the great distance to the heading, the crews working there were allowed travel time after the bore had been advanced 18,000 feet. This was progressively increased from one hour per shift to 2½ hours, the latter allowance taking effect when the 35,000-foot mark was reached. During the closing weeks, it took 50 minutes to haul a trainload of muck to the portal. Despite the great distance to the working face, the rate of progress held up well to the last. In April, 1944, an advance of 954 feet, or an average of 39.75 feet per day, was made and 99 sets of steel were erected. In May, with the heading 41,577 feet from the portal on the first of the month, the crews made 1053 feet and placed 105 sets of steel. The best record for a single day's advance was established by the Magoffin forces on October 10, 1941, when they drove 74 feet in 24 hours, completing eleven full rounds. The day and graveyard shifts each drilled, shot, and mucked four times for an advance of 26 feet each. The swing shift might have done equally well had it not lost an hour when a mucking machine broke down. This held it down to three rounds and an advance of 22 feet. The following figures summarize the operations conducted at the east end: Linear feet of supported tunnel driven, 19,347; linear feet of unsupported tunnel driven, 23,657; total linear feet driven, 43,004; shifts worked, 2987; days worked, 1058; average advance per shift, 14.4 fe average advance per day, 40.6 feet; be month's progress, 1554 feet in May, 194

The work on the west end started la than that on the east end and there w also an interruption at the conclusion o the first contract while Stiers Bros. Co struction Company assembled its pla and equipment to replace Platt Roger Inc. Soon after the resumption of opera tions in August, 1943, following th December 31, 1942, stop order of th Government, there was another brea in the activities. Early in October fir destroyed the wooden timbering insid Tunnel 10 of the Denver & Rio Grand Railroad on the east side of the range and bad cave-ins resulted. As the lin was carrying about 30 percent of th freight moving to and from the We Coast, it was imperative that the tunne be restored to service as soon as possible At the request of the Government, Mr Austin took his entire force there to re pair the damage, and they were engage in that work until November 29.

As the Alva B. Adams Tunnel slope from west to east to provide for gravity flow of water, the forces advancing fro the west end not only had to haul al muck uphill but also had to contend with water at the face and to remove it b pumping it to the portal. More wate was encountered there than on the eas side, and at times it was waist deep a the heading. Pumping stations wer established at various points as the bor progressed, and at the conclusion of th work there were seven, with a total o eighteen pumps, between the portal an



OSCAR W. CHAPMAN
Assistant secretary of the U. S. Department of the Interior photographed in the tunnel during the holing-through trip.

ENGINEERS SHAKE

C. H. Howell (right), supervising engineer for the Bureau of Reclamation on the Colorado-Big Thompson Project, shakes hands with E. R. Stuver who served three years as resident engineer at the west portal.

the 23,500-foot mark, each station being supplied with at least one spare unit. Three I-R air-operated sump pumps removed the water from the heading back to the first station, and from there it was pumped out to the portal by stages. The heaviest flow handled was about 2500 gpm. However, the contractor had to be prepared for any emergency, and a 20-inch line was carried in ready for use in case of need. One of the largest flows of water was fortunately removed without it ever getting to the heading. This was a pocket that was pierced by a pilot drill hole in advance of the face when it was about 18,900 feet from the portal. The pressure was so great that it shot the drill steel back beyond the drill carriage. The hole was connected to the water line, and the pressure behind the water forced it to the portal without any pumping.

Of the total footage driven from the west portal, 19,212 feet was advanced by the Stiers forces. This was accomplished in 1528 shifts, or an average footage of 12.58 per shift. The best monthly record on the job was made on the west end in March, 1942, when 1624 feet was driven. During the same month the best day's progress of 63 feet was registered in that heading.

The two contracting firms that completed the excavation of the tunnel have been awarded negotiated contracts for lining it with concrete. They will start at the center and work toward the portals. For transporting aggregates and cement into the bore they will use special bodies on the trucks of their muck cars. Each car will carry the dry materials for two 1-cubic-yard batches, with the cement and aggregates in separate compartments. Mixing will be done in 1-cubic-yard machines in the tunnel, and water will be added at that time. The invert section will be laid first, after which the walls and arch will be poured by forcing the concrete into the forms with Pumpcrete units.

It is estimated that concreting will require about one year. Meanwhile, the Bureau of Reclamation is proceeding with certain other features of the Colorado-Big Thompson Project. Shadow Mountain Lake, which will impound the flow of the north fork of the Colorado River and enlarge Grand Lake about four times, is being created under contract by the Shea Construction Company. Upon its completion, about 80,000 acre-feet of water a year will be available for diversion through the tunnel. The building of Granby Dam, which will be the main source of water supply, will be deferred until after the war. When it is finished, it is expected that approximately 310,000 acre-feet of water will be diverted through the tunnel annually.

As a temporary means of getting the water from the east end of the tunnel into the Big Thompson River so that it will flow down to storage reservoirs that will supply the various irrigation canal systems now in service, several miles of wood-stave pipe will be laid on top of the ground. This makeshift will be used until after the war, when the permanent conduit and tunnel system provided for in the original plans will be constructed. It will deliver the water to the river at a point below Estes Park Village and outside the boundaries of Rocky Mountain National Park, whereas the piping system that is to be built now will put it in the stream several miles above Estes Park.

The power-development features on the eastern side of the range will not be undertaken until there is a demand for the electrical energy that is to be generated. On the western side of the divide has been completed Green Mountain Dam, which impounds water that will be released into the Colorado River as it is needed to replace that which will be diverted through the tunnel. Two 12,000-kw. generators are now in service there. The current is being sold to the Public Service Company of Colorado and goes out over its line that was constructed from Dillon for the purpose of supplying power for the building of the dam.

Since the retirement of Porter J. Preston as supervising engineer of the Colorado-Big Thompson Project, C. H. Howell has been serving in that capacity. E. R. Stuver was resident engineer at the west portal for three years, and was succeeded by G. R. Highley. Frank J. Matejka is resident engineer at the east portal.

Editor's note: Previous articles on the Colorado-Big Thompson Project and the Alva B. Adams Tunnel (formerly the Continental Divide Tunnel) appeared in the issues of March 1938, March, 1941, and November, 1943.

JOHN R. AUSTIN

Manager of operations for Stiers Bros. Construction Company at the west end of the tunnel who was absent at the time of the holing-through because of illness.

Propellers for Many Ships

Robert G. Skerrett

Official U. S. Navy Photo

THE bow wave of a battleship or the disturbance made by a small motor torpedo boat racing along at full speed is visible evidence of the energy expended in driving the vessel onward through and upon the water. And well may one ask: How does a craft maintain herself at a steady clip against wind, wave, and tide, hour in and hour out?

The majority of us would probably answer that question somewhat in this fashion: Because of her high-pressure boilers and the efficient engines that impart their power to the driving shaft. This would be true only in part. No matter what may be the energy capacity of the teeming boilers and the efficiency with which the engines make the most of the steam supplied them, still the ship would be impotent to drive herself were it not for the propeller at the end of each tail shaft at her stern. A propeller transforms shaft horsepower into propulsive thrust against the theoretically incompressible fluid upon which the vessel floats and through which she must forge ahead under all conditions of the sea and the weather. This inescapable fact should give us a better idea of the importance of a propeller in transforming the power of the engine into speed of motion.

Well within the memory of many shipbuilders and marine engineers still living, the screw propeller was looked upon as a somewhat mysterious and complex product that at times performed well and on occasions gave far from satisfactory results. In short, it was a mechanical feature of much uncertainty of action. In those days the propeller designer had to make liberal use of "rule-of-thumb" procedure—of his own experience, plus perhaps a measure of inventive urge. He knew little, if anything, about the reactions between the revolving screw and the disturbances in the water that gravely qualified the conception of that medium as an incompressible fluid; and he scarcely had an inkling of how the craft herself could set up eddies and other motions in the water that would also alter the efficiency of the propeller and its grip upon the water that did not reach the screw streamlined and, in effect, "solid."

And then came those men of vision and scientific minds—William J. M. Rankine, Scotsman, and William Froude and his son R. E. Froude, Englishmen—who by theoretical analysis and subsequent model-tank researches discovered the secrets of some of the variables associated with the propulsive actions of a screw propeller revolving at the stern of a vessel. That was the beginning of a new and tremendously promising era in the application of the propeller to the driving of ships. The Froudes, especially, blazed the way for laboratory work that was to make it practicable to design for each given craft a screw that would best utilize engine power economically in driving her at the desired maximum speed. Others, following in the footsteps of those pioneers, have pushed forward with ever-increasing benefits.

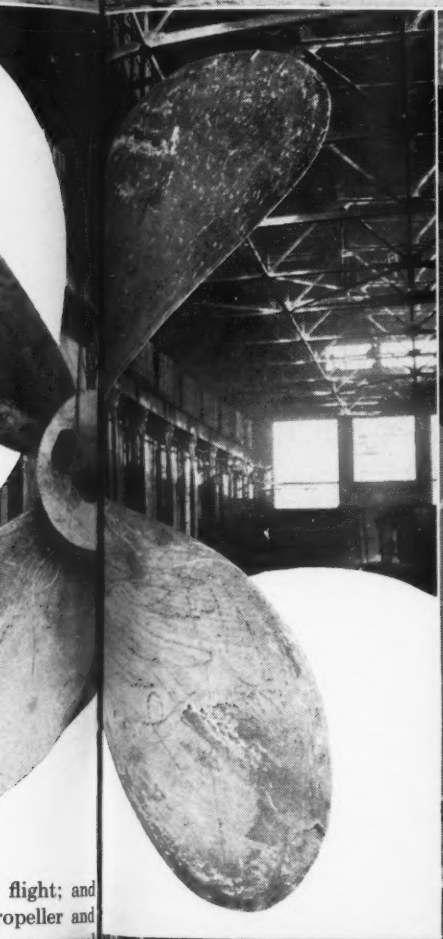
Research in American model-experimental basins, both government and private, aided by intricate apparatus, pretest the capabilities of any propeller and establish with still more certainty what performances may be expected of a given screw designed for a given ship. Aviation has stimulated investigation of the properties of the propeller as a means of transforming power into flight; and even though the aircraft propeller and the screw for the water-borne vessel operate in entirely different mediums, still the study of the former has yielded certain theoretical data that have useful application in designing ship propellers.

The purpose of this prelude is to give a hint of the complexity of the problem of planning a screw for a vessel, and it should be stressed that the number of blades and the prescribed form of every section of each blade are intimately linked with its functioning in service when it revolves so many times a minute to give the craft her desired full speed without wasting power. From this can be gathered with what nicety such a wheel must be produced in a foundry and its associate machine shop so that it will perform with precision when

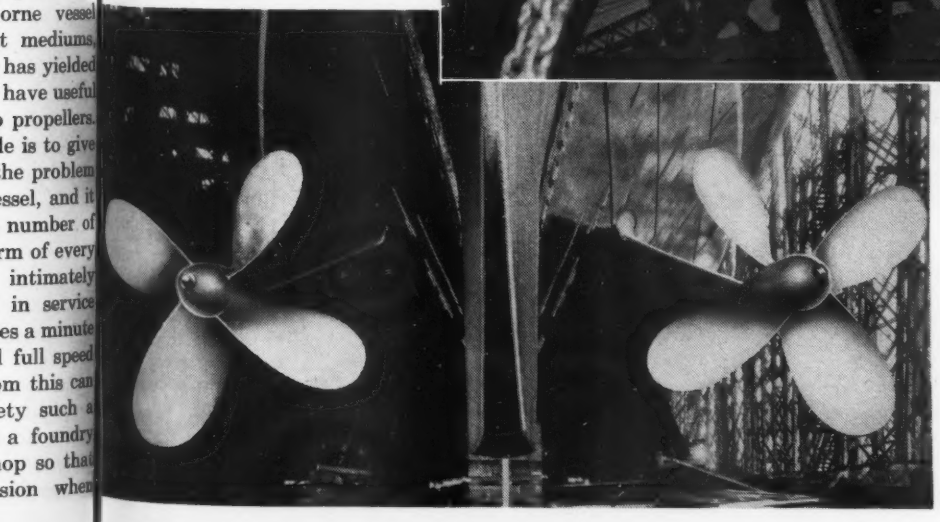
SHIPS AND PROPELLERS

Propellers for many classes of war vessels are cast and finished by the Cramp Brass & Iron Foundries Division of The Baldwin Locomotive Works. Many of them have gone into Liberty ships, such as the one shown at the left. Our Navy PT's—patrol torpedo boats (far left) have screws that churn the water to give them a speed that will cause their bows to rise high as they rush forward. Below is pictured a rigger riding a propeller that is being hoisted into position for securing it to the tail shaft of a Victory Ship. The twin screws of a fast United States liner are seen at the bottom. At the center is a large propeller casting leaving the Cramp cleaning shop for the machine shop where it will be finished.

Left, U. S. Maritime Commission Photo



U. S. Maritime Commission Photo



secured to the tail shaft. Experience and craftsmanship of a high order are needed to assure satisfactory results and that rapidity of output now demanded as a war measure. We are going to see how these things are accomplished by the Cramp Brass & Iron Foundries Division of The Baldwin Locomotive Works of Philadelphia, Pa., the largest manufacturer of propellers in this country.

In 1931, The Baldwin Locomotive Works acquired the Cramp Brass & Iron Foundries, and thus came about a consolidation of two famous industrial con-

cerns that were virtually contemporaries, both having started in Philadelphia about 100 years previously. In the course of time, the latter became a specialist in the making not only of iron castings but also of brass or bronze castings of many different compositions—such being the result of close collaboration between the metallurgist and the manufacturer of machinery requiring metals of varying physical properties and capable of meeting specific needs. The brass foundries, for example, turn out castings calling for 115 compositions, which gives some idea of the diversity factor of the demand.

Prior to Pearl Harbor, the Cramp Brass & Iron Foundries Division was producing propellers at an average rate of thirteen a month. Since that time the plant has been making as high as 125, and approximately 95 of them have been the large wheels for ships under construction for the U. S. Maritime Commission, while most of the others have been designed for vessels for the U. S. Navy—for battleships, battle cruisers, heavy cruisers, light cruisers, aircraft carriers, destroyers, destroyer escorts, destroyer tenders, submarines, submarine tenders, and seaplane tenders. The foundries have also produced screws for Coast Guard cutters.

All bronze castings that exceed 300 pounds in weight are poured in the large brass foundry, which has an area of 110,000 square feet and a daily melting capacity of more than 150,000 pounds. Propellers are cast in the main bay, one of two of similar size with an intermediate smaller bay, all under one roof. Spanning the foundry overhead are several traveling cranes that move back and forth shifting materials, flasks, and ladles filled with molten metal that are spotted precisely where the pouring is to be done. Restless as their continual movements seem to be, they are carried out in an orderly manner without any waste motion.

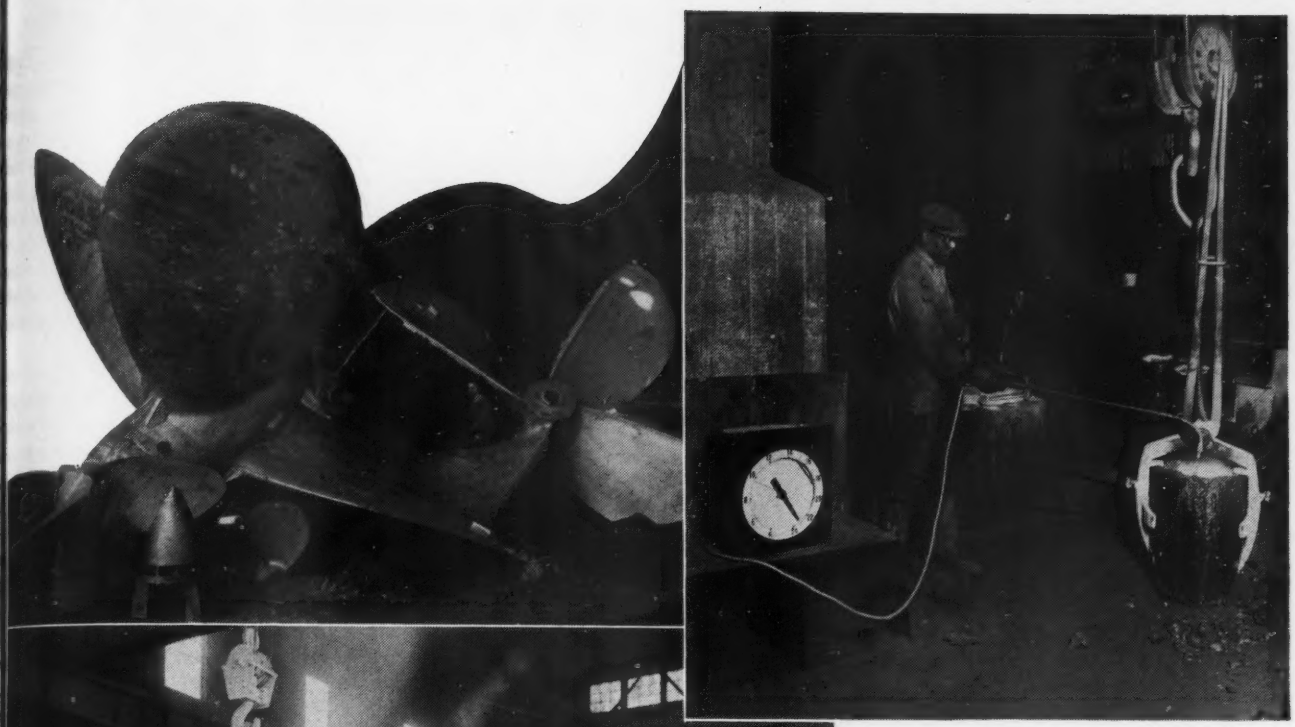
Manganese bronze is used for ship propellers because it is strong, will stand considerable abuse without damage, and is noncorrosive. Copper, zinc, lead, aluminum, manganese, tin, and iron enter into the composition in prescribed proportions, and some of the components volatilize during melting and escape up the chimney, but they serve a purpose. The manganese and the aluminum act as deoxidizers that purge the metal by helping to free it of gases which, if not eliminated, might cause blowholes and other defects in a casting.

The bronze is melted in one of two reverberatory furnaces, each with a capacity of 40,000 pounds. Melting time from the cold to the teeming stage is six hours; but a furnace when reused while still hot can produce a second melt in 4½ hours. The metal has a temperature ranging from 1800 to 1820°F. when ready for pouring. At intervals before tapping, small slabs are cast at the furnace, and as soon as these are cool enough to handle they are broken with a sledge to reveal the granular structure of the fracture which tells the foundryman whether or not the composition is right, or what has to be added to make it right. The slabs are also bent to show whether the bronze has the required ductility. Each furnace can, if desired, produce two heats in a day of 11 to 12 hours. Ingot metal of definite composition is used to charge the furnace and is supplemented with scrap in the form of gates, risers, fins, etc., that has been removed from screws as they come rough from the molds or during the finishing operations in the machine shop. This material can be fed into a furnace by lifting a removable section of its roof.

Most of the propellers turned out at the plant are for Victory and Liberty ships, the greater percentage being made for the latter. The finished screw for a Liberty Ship is 18½ feet in diameter while that for a Victory Ship is 20½ feet. In the rough, they weigh 28,000 and 54,000 pounds, respectively. The pattern for each is an unfinished bronze casting that, if ground and polished, could serve as a propeller for one of these vessels. All its dimensions are larger than those of the screws that it helps to produce, the excess allowing for shrinkage in the metal between its molten and solidified states. The larger mass of the rough casting affords compensation for any warping while it is in the mold and also offers leeway in performing the ma-

PREPARING MOLDS

Shown at the left is the drag or lower section of a mold for a large propeller casting. It is being air-dried. Where only a few wheels of a given size are to be produced, it is the practice to use a single-blade pattern, generally of wood, and to rotate it in making the successive molds for a complete screw. Workmen are ramming such a pattern at the top. In the foreground of the picture is a finished drag section of a blade mold.



CASTING OPERATIONS

The pouring of a Victory Ship propeller is shown directly above. The molten bronze from the ladle enters the bottom of the mold through a pouring basin. Men on top of the mold are watching the metal as it rises in the hub section and with skimmers remove any impurities floating on the surface. The cast-iron weights on the mold serve to offset the hydrostatic pressure of the fluid bronze. At the top, right, a workman is taking the temperature of a crucible of metal preparatory to pouring a moderate-sized casting. As the rough castings come from the molds they appear like those seen at the top, left. The small screw at the lower left in the picture is for a naval escort craft. The conical casting next to it is the fairwater cap that will be affixed to it later.

chining and finishing operations that are counted upon to provide a wheel that is in close agreement with the drawings and specifications. The pattern can be used again and again with little likelihood of injury or deformation, and its rigidity results in a casting of great accuracy. Furthermore, it is said to save both time and floor space in the foundry.

The pattern for the 4-bladed propeller is set up with great care and with the leading faces of the blades turned downward in the cast-iron flasks. These are arranged in the form of a cross on the foundry floor, with each arm of the cross encompassing one blade of the wheel. The flask sections of the mold are rectangular, and the assembly is held together by bolts or by dogs and wedges. Vertically, the mold is built up of two main parts—the "drag" or lower section and the "cope" or upper section. Unlike most foundries doing similar work, it is the practice in this plant to pack a mixture of cement and sand, not just sand, about the pattern—the cement constituting about 11 percent of the mix. With the water added, the material has the consistency of a weak concrete, but it is decidedly strong when judged as a mold fill. It is rammed against the surfaces of the mold, and similar but broken sand-cement is packed back of the new mixture and out to the mold limits. This gives the necessary support to the casting and, because of its porous nature, permits steam and gases to escape readily. The cement-sand facing produces a superior casting even in the rough state.

The mold is rammed, and after "setting" for several hours the copes are lifted off, the pattern is removed, and all the exposed surfaces of the mold are dressed wherever there are any irregularities and coated to prevent the molten metal from sticking to the sand. With this facing operation finished, the two sections are exposed to the atmosphere for 24 hours to promote air-drying. Then they are reassembled, closed, locked together, and further dried. But this does not complete the work on the mold structure.

Off at one side is the very important pouring basin—a stack of circular cast-iron flasks into which the bronze is first teemed. Next, the metal follows a somewhat wandering course down through the gate or channel that delivers it to the bottom of the mold, whence it mounts to fill every part of the hub and the blades. The basin and the gate are lined with the sand-cement mixture; and there is an excellent reason for not leading the metal straight from the pouring flasks to the mold. The zinc in the manganese bronze, because of the high melting temperature of the composition, quickly tends to oxidize when brought in contact with air, and air may be carried into the molten metal by agitation. Zinc oxide, if formed and held within the metal, may

CLEANING CASTINGS

Below, a 60-inch circular saw, provided with teeth of high-speed tool steel, is cutting the sinkhead from a Liberty Ship propeller casting. Pneumatic chipping hammers do much of the cleaning. One of them is shown at the bottom, right, removing the thin fin at the edge of a blade. In the other picture a similar tool is breaking the core out of a fairwater cap before the two projecting sinkheads are detached.

cause defects. Therefore the latter must flow from the pouring basin to the bottom of the mold by steps that will prevent agitation and the formation of zinc oxide in the body of the casting. This is where metallurgy and the art of the foundryman come into play.

The center of the hub of a propeller is cast hollow by inserting in the mold a carefully predried core of the cement-sand mixture. This core has to be held securely by means that will prevent it from shifting or floating as it is enveloped by the rising tide of the bronze. In fact, the hydrostatic head of the metal, because of its unit weight, is so great as it gradually fills all the cavities in the mold that the top of the latter has to be held down during pouring by a number of rectangular iron blocks that weigh as much as 50,000 pounds.

With everything in readiness for the critical stage of casting, an overhead crane brings a large ladle from the furnace and halts it at the exact position that will enable two workmen to tilt it and to teem its contents into the pouring basin steadily and under perfect control. When filled, the ladle will hold enough bronze to mount above the top of the propeller hub and partly to form the riser or sinkhead where the metal will remain fluid for some time and feed downward and backward to fill any cavity formed by shrinkage of the cooling and solidifying bronze. But don't let us go too fast.

Teeming from the ladle into the pouring basin continues until the latter, which is temporarily plugged where it connects with the gate, is sufficiently full to maintain a steady flow down into the gate. Then the plug is withdrawn and the metal is free to start its course into the mold. A worker continually watches the surface of the bronze in the pouring basin, and with a skimmer—a long-handled wooden tool that looks like a hoe—scrapes from it any accumulating dross or oxide. Men on top of the mold, also provided with skimmers, peer down into the sinkhead cavity and clear away any impurities floating on the surface of the mounting metal to prevent the dross from being swept into the blade spaces. This operation goes on until the bronze has risen well above the hub section of the screw and has reached the sinkhead.

The big ladle contains enough metal actually to form the propeller and can be poured in about five minutes. Half an hour after it has been emptied, five crucibles, each holding 1000 pounds, are successively teemed into the riser to maintain a header of molten bronze that will fill any cavities due to shrinkage. The extra 5000 pounds also slows up cooling and minimizes any tendency of the blades to warp. After the last of the metal is teemed, the casting is left undisturbed for some time before it is broken out from the mold, lifted, and transferred by one of the traveling cranes to the adjacent cleaning shop. There the

MACHINING

In the machine shop the rough castings undergo various operations that transform them into the finished, precisely balanced wheels prescribed by government specifications.

gate, like a winding intestine, is detached and the massive sinkhead is cut off by a 60-inch circular saw with inserted teeth of high-speed tool steel, the screw being supported the while on a horizontal bar passing through the hub. The sinkhead of a Liberty Ship propeller casting averages 3 feet in diameter and about 2½ feet in height.

In the cleaning shop, workmen with pneumatic chipping hammers remove the thin and ragged fins attached to the edges of the blades, as well as some of the rough spots on their broad surfaces. On each of the four blades of the screw is cast a projecting rectangular lug, technically known as a "test coupon," which is about ½ inch thick, 6 inches long, and 3 inches high. These also are cut off with chipping hammers and are sent to the laboratory for analysis and testing so as to ascertain the true physical characteristics of every blade. With that work done, the wheel is moved to the machine shop, which is unsurpassed in its facilities for finishing ship propellers. At that stage the screw weighs something like 23,500 pounds, or about 4,500 pounds less than it did in the rough state. During the painstaking and precise work in the machine shop, it undergoes further reduction, and by the time it is ready to be sent to a shipyard it weighs 22,000 pounds.

The figures just mentioned give a hint of what has to be done in producing propellers that are far larger than those for Liberty ships—that have a diameter of 22 feet and weigh as much as 72,000 pounds as they come from the mold. Screws of this size, the biggest ever manufactured at the plant, are now being made for a number of special vessels. The operations in connection with them generally follow the lines already described; but when one or a few of a given size and form are to be produced, the pattern is likely to be carefully fashioned of wood instead of metal and to consist of one blade and a section of the hub. In other words, the mold for each blade is rammed separately, the pattern being rotated in each succeeding drag-and-cope section in conformity with the prescribed position of the blade. Plainly, all the work involved takes more time than when a complete pattern is used.

In the case of a Liberty Ship propeller, for example, the Government prescribes very small tolerances that have to be met to make the wheel acceptable. The plus and minus tolerances on any blade in the matter of width do not exceed ⅛ inch, and the tolerance in the pitch—the angle at which a blade is set to the axis of the hub—is ½ of 1 percent from that shown on the plans. A minus tolerance of 1/16 inch and a plus tolerance of ⅛ inch are the variations in the thickness of a blade that will pass inspection. Likewise, in the machine shop, the rough propeller casting must go through a balancing operation that determines to a nicety the axis of the finished wheel—the base line of all the work in chipping, grinding, and polishing the blades, in facing the two ends of the hub, and in giving the hub the tapered bore to receive the tapered end of the tail shaft of the ship. The facilities at the plant of The Baldwin Locomotive Works are such as to make it practicable to deal with all these operations with precision, as well as expeditiously. To the layman, unfamiliar with the functions of a screw in transforming engine power into thrust or forward impulse, some of the refinements mentioned may seem altogether unnecessary. In this he errs.

A heavy propeller may be likened to a

ALMOST FINISHED

These bronze propellers, glistening like gold, are almost ready to be shipped out. Two of them are shown with their fairwater caps in place.

flywheel in some of its actions; and in the case of a Liberty Ship the screw is revolved 76 times a minute with energy delivered to it by an engine that develops 2500 ihp. The tip of each of the four blades circles through the water at a speed of 50 miles an hour and churns it into a whirling, reacting "wake" while imparting headway to the vessel. The propeller must therefore be so nicely balanced that it will not act like an eccentric flywheel but turn smoothly, with each blade striking the water a blow corresponding exactly to that dealt by each of the other blades. Without this balance the screw would deliver jarring and dissimilar blows to the water, and these might set up vibrations that would be a source of discomfort to the people on board the ship, if they did not induce structural injuries to the vessel herself.

There are additional features about one of these big propellers that should be mentioned. The core that was inserted in the center of the mold carried a boss in the lower section that produced lightening pockets in the hub. After the wheel is set on its tail shaft, these pockets are filled with tallow that is forced into them under pressure through four holes drilled from the outside of the hub. The tallow arrests any sea water that might work its way in between the propeller and the shaft and lead to corrosion. With the tallow holes drilled, the keyway is cut in the hub by which the screw is firmly secured to the tail shaft. Twelve equally spaced holes are then drilled in the after or outboard face of the propeller hub and threaded for the studs by which the fairwater cap is attached to the screw.

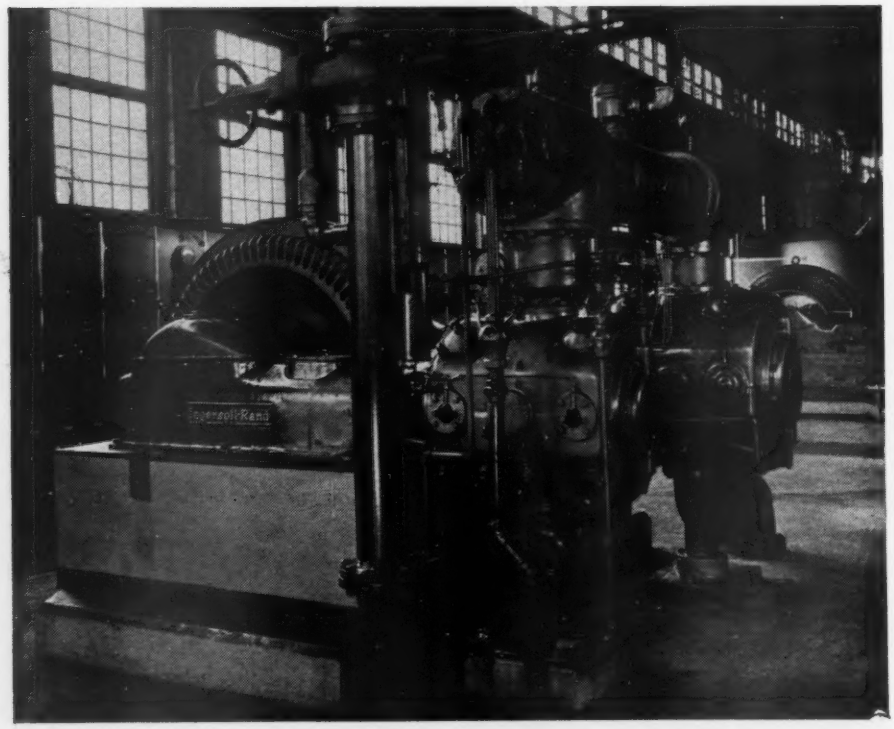
The cap, which is a large and heavy casting, tapers something like the head of a big projectile and serves to give the water sweeping over the hub a more or less streamlined flow. Before it leaves the machine shop it is made wonderfully smooth and is highly polished to minimize frictional resistance. In fact, all surfaces of a propeller have the appearance of shining gold, and the leading edges are so formed and finished that they will cleave the water almost as smoothly as a razor blade. This applies to all the wheels produced at The Baldwin Locomotive Works for our fighting ships and for the indispensable cargo carriers and other types that contribute in their particular ways to winning the war.

Not so very many years ago but little attention, comparatively speaking, was given to the superficial finish of propellers, and as they increased in size even less refinement in this respect was acceptable. Today the marine engineer knows that surface irregularities may induce reactions that will promote corrosion and pitting, which may have serious effects. Therefore everything possible is done to assure a finish that will lessen frictional resistance between metal and water and otherwise streamline th motions of the fluid in which the scre revolves for the purpose of exerting maximum of impulse.

In the large brass foundry of th Cramp Brass & Iron Foundries Divisio the melting capacity amounts to as much as 3,000,000 pounds in a month while the smaller one turns out monthly an average of 500,000 pounds of castings Naval vessels require many brass and bronze castings, and these may range in weight from half an ounce to a ton. In making them, foundries have recourse to many different methods—each having advantages in specific cases that contribute to excellence as well as speed of output. A striking example of this is to be found in the production of destroyer propellers. The screws for these fast craft were formerly cast according to approved practice and then machined to true form. Now, because of the need for haste, a way has been devised by which the wheels can be cast still closer to the final form in order to cut down the finishing time. This is being done at the Cramp foundries, but the method is a trade secret that is being carefully guarded.

Compressed air is indispensable in any modern foundry, whether it is making brass, bronze, or alloyed-iron castings, because it has innumerable uses such as driving pneumatic tools of various sorts, operating jarring machines doing sand-blasting, and performing other helpful services all of which tend to speed along and to turn out first-class work. At The Baldwin Locomotive Works the compressor plant is a sizable one, having an average output of 20,000 cfm. at a working pressure ranging from 95 to 102 pounds. It houses four Ingersoll-Sergeant steam-driven units three of which have a capacity of 1400 cfm. each and one of 2200 cfm. These machines were moved from the old establishment in the heart of Philadelphia to the new and far greater plant in the suburb of Eddystone on the west shore of the Delaware River. In addition to these veteran compressors there are eight up-to-date electrically driven units varying in capacity from 800 to 5000 cfm., and a group of four ER machines—two delivering 600 cfm. and two 1000 cfm. each—that is furnishing air for certain special work being done for the Army. It may be said in all truth that this big compressor plant supplies the vital operative breath for the mechanical activities that make The Baldwin Locomotive Works one of the nation's centers of defense effort.

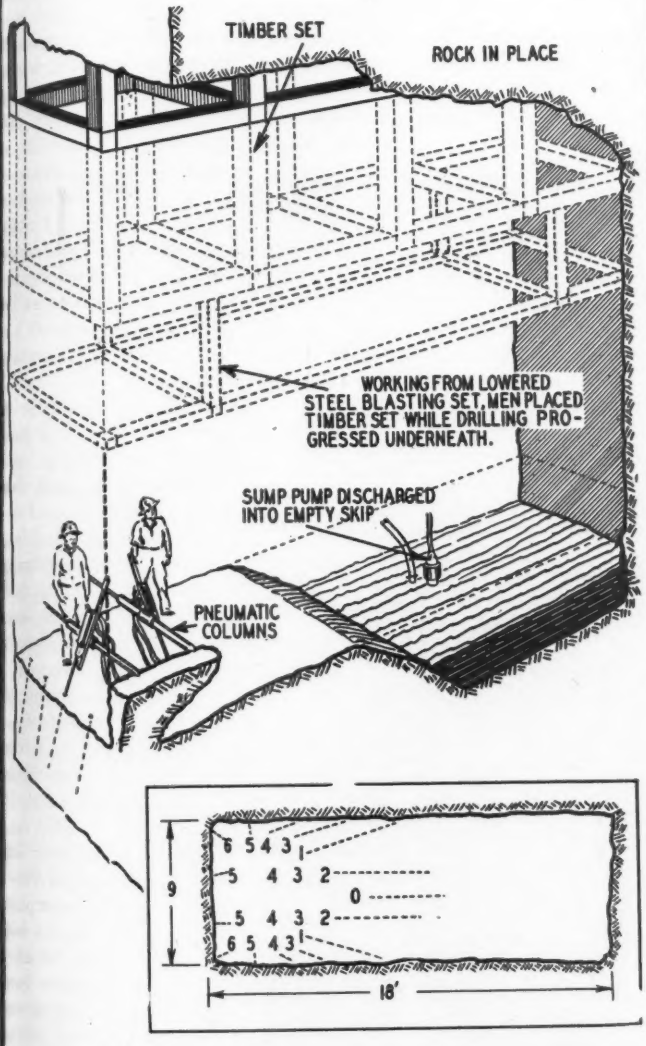
Acknowledgment is hereby given to James J. Nelson, divisional vice-president; Joseph C. Sharp, foundry superintendent; Malcolm K. Wright, advertising manager, and their associates for the help they have given in the preparation of this article.

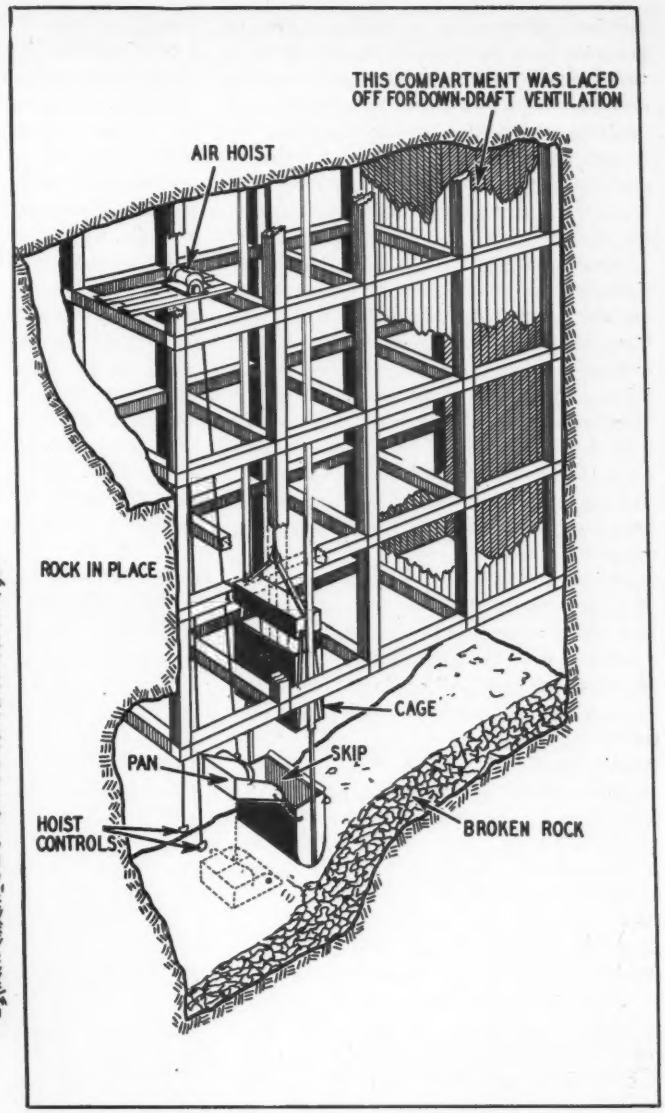


COMPRESSED-AIR SUPPLY

Numerous compressors furnish 20,000 cubic feet of air per minute for diversified services in the foundry and associate shops. The line pressure ranges from 95 to 102 pounds. In the foreground is one of the modern synchronous-motor-driven machines, a Type XRE, with an overhead intercooler between the high-pressure and low-pressure cylinders.

Shaft Sinking with Drifter Drills





DRILLING AND MUCKING SCHEMES

The upper left-hand sketch represents a section across the shaft bottom at the Atlas Mine. It illustrates how two drifter drills were each mounted on a pneumatic bar and how the bench system of drilling permitted one-half of the bottom to be high and dry while the other half served as a sump. The lower sketch is a pattern of the average drilling round, and the numbers indicate the order is which the holes were fired with electric delay detonators. The sketch above shows how the bottom looked after the drilling round had been blasted. Considerable muck was thrown to the right, producing a sloping surface. Muck was hand-loaded into a pan, which was then elevated by an EU air hoist for dumping into a skip. The latter was lowered on guide extensions.

HEAVY hand-held rock drills of the Jackhamer type have long been accepted as standard equipment for sinking mine shafts and winzes. Such drills weigh considerably more than similar machines used for the general run of work and are oftentimes made even heavier by hanging weights on them. Because of the service to which they are put they are called "sinkers."

For average rock conditions, and with experienced miners to operate the drills, sinkers are undoubtedly the most effective machines for shaft work. Recently, however, several sinking operations in the Coeur d'Alene District of Idaho have been carried out with drifter drills, and the results indicate that they may be preferable to sinkers under certain conditions.

Drifter drills are especially suitable for use in "hard-ground" mines where the drilling time constitutes a large part of the complete cycle of getting out a round. This is more true now than normally because of the high percentage of "green" miners employed owing to the inroads made upon labor forces by the war. A sinker can ordinarily be put into action quicker than a drifter because all the operator has to do is to pick it up and start drilling, whereas the heavier drifter must be mounted. Mounting takes considerable time when conventional screw-type columns are used, but there are now available quickly adjustable pneumatic columns that greatly expedite the setting-up operation.

Once they are set up, drifter drills will put down holes faster than sinkers. Here, again, the performance margin is greater when inexperienced miners are handling the equipment. Drifters are fitted with a hole centralizer that simplifies the collaring operation. Holes

can be spotted exactly, which makes it possible to adhere closely to a hole pattern that will produce optimum blasting results. Being mounted in a stationary position, the drifter keeps the steel directly in line with the hole at all times, and this serves to decrease steel breakage and to reduce wear and tear on the drill, which is reflected in lower upkeep costs.

The Bunker Hill & Sullivan Mining & Concentrating Company, the Hecla Mining Company, and the Sullivan Mining Company have employed drifter drills and pneumatic columns on three sinking jobs in Idaho during the past four years. The first attempt was made by Bunker Hill & Sullivan in driving an opening on an incline of 41°. This was done by sinking an auxiliary shaft, drifting to the base of the incline, and then driving the latter as a raise. Drifters were utilized experimentally in sinking the auxiliary shaft late in 1940. Two DA-35 power-feed drills were mounted one each on a 3-inch pneumatic column. After a row of holes had been drilled from the initial set-up, the column was collapsed and moved to a new set-up without removing the drill.

The next job was a vertical shaft 800 feet deep at the Atlas property of the Hecla Mining Company. The first 400 feet was sunk with Jackhamers and the remaining 400 feet with drifters, so there was an opportunity to make a direct comparison between the two types of drills. An analysis of the records shows that the drifters effected no appreciable saving in drilling time because it took longer to set them up and to start drilling than it did to get underway with the Jackhamers. However, an interesting discovery was made, namely, that the round was mucked out quicker when drifters were employed. This was attributed to the fact that the miners did not become fatigued when working with drifters and were able to muck at a faster rate than when tired from the handling of sinker drills.

Two DA-35 power-feed drifters, both mounted on a D4 pneumatic column 3 inches in diameter, were used on the lower shaft section. Such a column, which is also called an air bar, consists of a pipe section containing a 1-piece tubular piston at one end. Admission of air extends it, and the pressure holds it tight against the opposed rock face. Wood blocking is not necessary, as a fishtail footpiece assures tight contact with the rock. The throttle valve is located conveniently for foot operation and has a built-in check valve that prevents the escape of air from the column in case the air supply is accidentally shut off.

For this particular job was worked out a benching method of excavating that proved advantageous. As shown in accompanying sketches, approximately one-half of the bottom area was drilled and blasted at a time. This tended to throw the muck pile into a sloping heap against the opposite side of the shaft instead of upward and against the timbering, thus reducing breakage of wall plates and of other structural members and also simplifying the mucking operation. As a result of the benching procedure, one-half of the bottom area was always higher than the other half. The lower section became a sump where water accumulated and could be removed by pumping. After a round was mucked, the higher half afforded a clean, dry space from which to carry on the drilling operation.

Four men per shift, working three shifts daily, were employed on this job, and they averaged 4.67 feet of progress per day. The average payment per man per shift, including bonus, was $10.91 and the average labor cost per foot was $28.27. The man-hours per foot of shaft sunk totaled 20.74, divided as follows: Drilling and blasting, 8.98; mucking, 6.67; timbering, 2.19; pipe fitting, 0.42; miscellaneous, 2.48.

In the third sinking operation, a 400-foot vertical winze was put down at the Sullivan Mining Company's Star Mine with four DA-30 power-feed drifters mounted two each on a D4 pneumatic column. Instead of resorting to the benching method, the entire bottom was drilled at one time. A comparison with the previous job reveals that the benching method was more desirable and more efficient and that the heavier DA-35 drills made a better showing than the DA-30 machines.

DRILL SET-UP

A DA-30 drifter mounted on a pneumatic column during a shaft-sinking job in the Atlas Mine of the Hecla Mining Company. The footpiece at one end of the bar may be seen in contact with the rock wall, and just above it is the air connection to the bar with a hose line running to it.

This and That

Beehive Coke Revives

The war has revived the beehive-coke industry, which was believed to be dying only a few years ago. In 1943 one-eighth of all the coke used in the nation's blast furnaces, or 7,000,000 tons, was made in beehive ovens. This was seven times the annual production prior to the war. In 1916 there were 65,065 such ovens in service, and their output was 35,000,000 tons, the greatest on record. By 1932 beehive production had virtually ceased. Most of the beehive plants were deliberately destroyed to avoid paying taxes on property that was considered to be no longer useful. By-product coke ovens, which save the gas and treat it for the extraction of numerous valuable constituents, had by that time become almost standard. When the wartime emergency brought about a demand for more blast-furnace coke, it was cheaper and quicker to rehabilitate old beehive plants and to build new ones than it was to erect by-product ovens. When conditions once more become normal, the former trend will probably be resumed and many of the beehive ovens will go out of service.

★ ★ ★

Truck Helps Truck

Butler Brothers, operators of iron mines on the Lake Superior Range, is experimenting at its Galbraith Pit property with a scheme for utilizing the power of an empty truck descending a slope to assist in pulling a loaded truck up the incline. The idea is similar to that used in connection with funicular railroads and balanced mine-shaft hoists. The 50-foot-wide roadway leading out of the Galbraith Pit runs in a straight line and on a 12 percent grade. Two parallel sets of 40-pound-rail tracks, spaced 13 feet apart, were laid on the slope. The entire width of the roadway was then covered with ballast to make its surface flush with the top of the rails, save for the 24-inch space between the rails of each track. Two metal cars weighing a ton each and mounted on four 20-inch wheels were built at one of the mine shops. One car runs on each track, and the two are connected by a ¾-inch cable that passes over a sheave at the top of the incline and is just long enough so that when one car is at the bottom of the grade the other one is at the top.

When an empty truck is ready to descend, it is driven astride one track and behind the car at the top of the slope. The loaded truck at the bottom has a gross weight of 30 tons and is placed in front of the car at that location. At a given signal the drivers of both trucks apply their power. The downgoing truck pushes its car ahead of it and, through the cable, draws the other car upgrade. The latter pushes the loaded truck in front of it and helps to move it up the incline. Thus the power of both trucks, plus the weight of the descending truck, which is 15 tons, is applied in hauling the loaded truck out of the pit.

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Air on the N. Y. C.

An article in the March issue of *Railway Engineering and Maintenance*, dealing with the mechanization of the bridge and building forces of the New York Central Railroad System, contains the following historical data: "Probably, as on other roads, it was the steel gangs that first began to benefit by the process of mechanization, owing to the fact that the introduction of pneumatic tools such as riveting hammers and allied equipment suitable for the use of such gangs antedated by some years most other types of power equipment that are used by the bridge and building forces today. An indication of the eagerness with which the availability of power tools was welcomed by the system, even in the early years, is shown by the fact that, before portable air compressors were developed, it was frequently the practice to use an air pump taken from a locomotive, and driven by a portable steam boiler, to provide the necessary compressed air to permit the use of pneumatic tools in steel repair and fabrication work. Ultimately, of course, these makeshift outfits were replaced with modern portable compressors."

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Rustless Metals Explained

Nickel and alloys containing it resist corrosion not because of the formation of a protective surficial film of oxide, as has been previously supposed, but because there are vacant spaces in the atom of nickel. This fact was recently disclosed by Dr. Herbert H. Uhlig, metallurgist of the General Electric Research Laboratory, who previously had determined that the stainlessness of stainless steel results from the electronic arrangement of the atoms in the alloy. Each atom has a nucleus around which revolve from 1 to 92 electrons, moving in from one to seven different orbits or shells. One shell is ordinarily filled with electrons before the next one begins, but in the case of certain "transition" elements there are vacancies in the shell next to the outer one. In nickel, which has four shells, there are only eight electrons in the third one instead of the ten it could hold, although the other shells are filled. These vacancies render nickel corrosion resistant and impart a similar property to some of its alloys. Two of them are monel (copper and nickel) and Hastelloy (molybdenum, nickel, and iron). The atom of copper has one more electron than that of nickel, and when the two elements are alloyed the extra electron goes to fill the vacancies in the nickel atom. However, so long as any vacancies remain in the nickel the alloy resists corrosion as well as does pure nickel. When the proportion of copper in the alloy reaches 60 percent, all the nickel vacancies have been filled and any increase in copper renders the alloy less resistant. In the alloy of nickel, molybdenum, and iron the effect is similar, according to Doctor Uhlig.

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Alaska Juneau Closes

Another famous gold mine, the Alaska Juneau, has fallen a victim of rising costs and has suspended work for the duration of the war. This action was taken when the National War Labor Board in Washington declined to modify a previous ruling granting miners a raise in pay of fourteen cents an hour. The management said that this increase would result in operating losses that would be greater than the out-of-pocket cost of a complete shutdown, so the mine was closed on April 8. The average daily wage of the miners in 1943 was $8.58.

The closing of Alaska Juneau interrupts a production record of nearly half a century and marks a pause in one of the great mining romances of our times. The company was organized in 1897 to work a huge deposit of ore at Juneau that averages around $2 in gold content per ton. For many years the operation lost money, but by gradually increasing the daily tonnage mined and milled, and by altering the milling process to include flotation, it was finally put on a paying basis. This accomplishment was generally attributed to the indomitable courage and technical skill of F. W. Bradley. Since his death one of his sons, P. R. Bradley, has been at the helm. When running normally, the mine produces and concentrates 8000 tons of ore a day. Ore reserves are estimated at around 45,000,000 tons.

Compressed Air at Work

Photographed by William LaVarre

On the Chilean desert the winds are very accommodating. They blow from the Pacific in the morning and toward it in the evening. Taking advantage of these conditions, nitrate miners living on the coast sail to and from their work, a round trip of some 40 miles, on a flat car, right. At one time the Germans were reported to be transporting supplies to the Russian front in sail cars; and in Paris, wind-driven conveyances similar to a tricycle have been substituted to a limited extent for automobiles since gasoline has became scarce. They are equipped with pedals for use against the wind or in a calm.

Photo from Compressed Air Institute

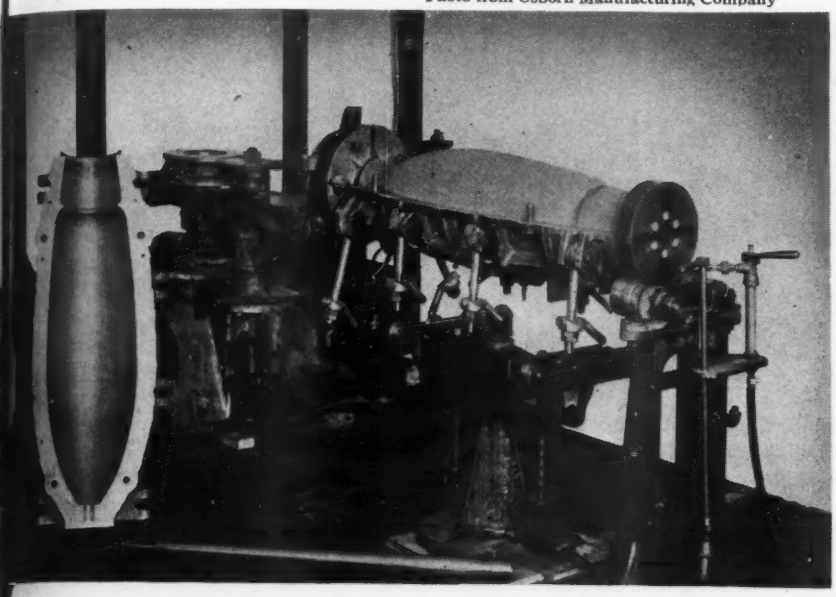
Every sheet-metal part of Billy Mitchell bombers and of Mustang fighter planes bears an index number that makes it readily identifiable. This system aids workers in locating the various members quickly during assembly operations and guards against errors. The index numbers are stamped on the pieces with a compressed-air numbering machine. The picture above shows a woman operating one of them in the Ingelwood, Calif., factory of North American Aviation, Inc.

Acme Pi

Sandhogs coming off shift are "locking out" after working under air pressure in the construction of a Chicago sewer. In this chamber the pressure is gradually reduced to that of the atmosphere to safeguard the men against compressed-air illness, commonly called "the bends." This precaution is compulsory, and if it were not observed the workers might suffer great pain, or even death, from the sudden expansion of nitrogen bubbles entering the blood stream from the lungs. The use of locks has virtually eliminated the bends as an occupational disease.

Openings in castings are formed by pouring the metal around cores of the proper shapes and sizes that are accurately positioned inside the molds. Because of the irregular shapes of the cavities, it would often be impossible to ream out the cores if they were of a solid material. They are therefore made of sand which, with suitable binders added, produces a core that is hard and strong enough for the purpose and yet of a texture so that it can later be disintegrated and removed from the casting. Many cores are now made by blowing the sand into a core mold instead of tamping it by hand or mechanically, as was formerly done. Pressures of from 90 to 120 pounds are commonly used, depending upon the size of the core. The picture directly below shows the upper half of an air-blown sand core for casting a large aerial bomb. It is ready to be removed from the core mold and to be placed in the casting mold.

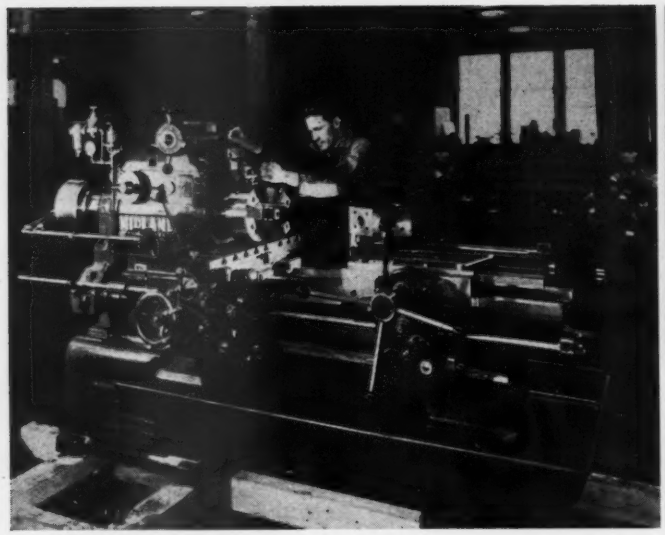
Photo from Osborn Manufacturing Company

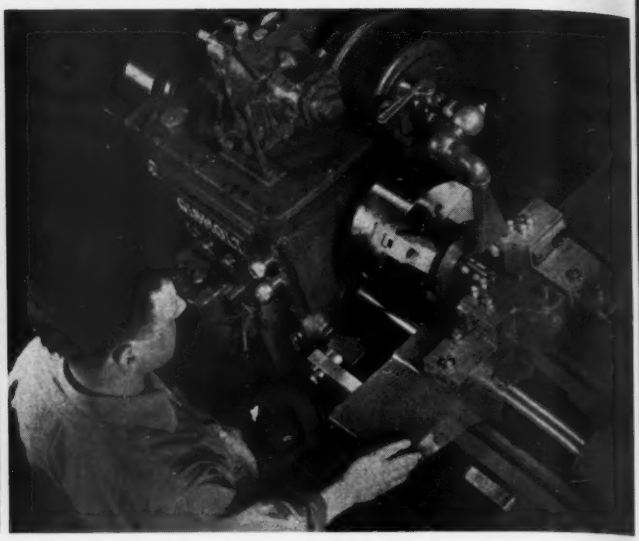


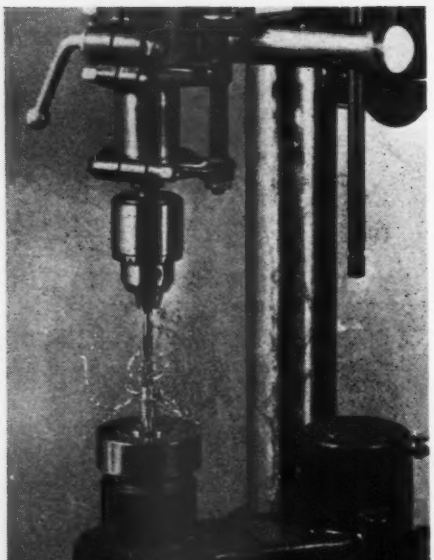
The principle of the pneumatic-tube system has been adapted for passing hot rivets from a forge to the points of application. The device, which is called the Penflex pneumatic rivet passer, is pictured at the bottom and has various advantages over the colorful hand-passing method. It promotes safety and eliminates waste, since every rivet definitely reaches its destination. In ships' holds and other confined spaces it improves health standards because the forge, with its fumes and gases, can be located at a considerable distance from the riveters. The base of the rivet passer is an air chamber, supplied by a hose connection from a distribution system. The heated rivet is placed in a head and opens a valve through its own weight. Pressure on a treadle admits air, and the rivet speeds on its way. The delivery line is an all-metal, flexible hose with corrugations that remove scale from the rivet as it travels through. The pressure of the air can be adjusted for the correct speed, which is about 15 feet per second. The device is effective for sending rivets a distance of 125 feet in any direction, and the delivery tubing may be curved, as desired, to go around corners or to reach hard-of-access places. Three sizes are available for rivets of varying diameters up to $2\frac{1}{16}$-inch head. The picture shows a rivet being put into the sending head. The man has a foot on the air-control treadle.

The worker below is using an air-operated wire brush to remove rust from one of the steel gates of Grand Coulee Dam in the State of Washington. He wears a hood to protect him against breathing in the iron-oxide powder and is equipped with a life preserver in case he should topple into the reservoir below.

Keystone Photo







TYPES OF CHUCKS

Typical applications of air-operated chucks. Photographs from Red-E-Air Chuck Company, Auker-Holth Manufacturing Company, and Logansport Machine, Inc.

Air Chucks for Machine Tools

THE compressed-air-powered chuck on today's industrial machine tool greatly speeds up the loading and unloading of work and at the same time relieves the operator of all physical strain in connection with chucking. The use of air chucks also permits the skilled machinist to give undivided attention to the actual machining operation of which hand chucking was formerly a laborious part. The physical energy thus conserved, in addition to the actual time saving, has made for high efficiency in war production.

The air chuck is quick acting and actuated simply by moving a valve handle or switch control. Compressed air serves to operate either air-cylinder or hydraulic-cylinder chucks and is suitable for the rapid handling of light and medium work and for holding very heavy work when the chucking effort is great.

Two styles of air cylinders are in general use. One is a single-acting cylinder that closes the chuck with air, which is then opened by means of a spring. The other is a double-acting cylinder that both opens and closes the chuck with air under pressure. The air requirement of each of the different styles and sizes of cylinders is low, as the accompanying table from the Compressed Air Institute shows.

It is difficult to estimate accurately the time that will be saved by means of air chucks because the speed of hand chucking depends upon the skill of the individual worker, the tool in service, and the work to be held, while the compressed-air chuck is to all practical purposes instantaneous in its action.

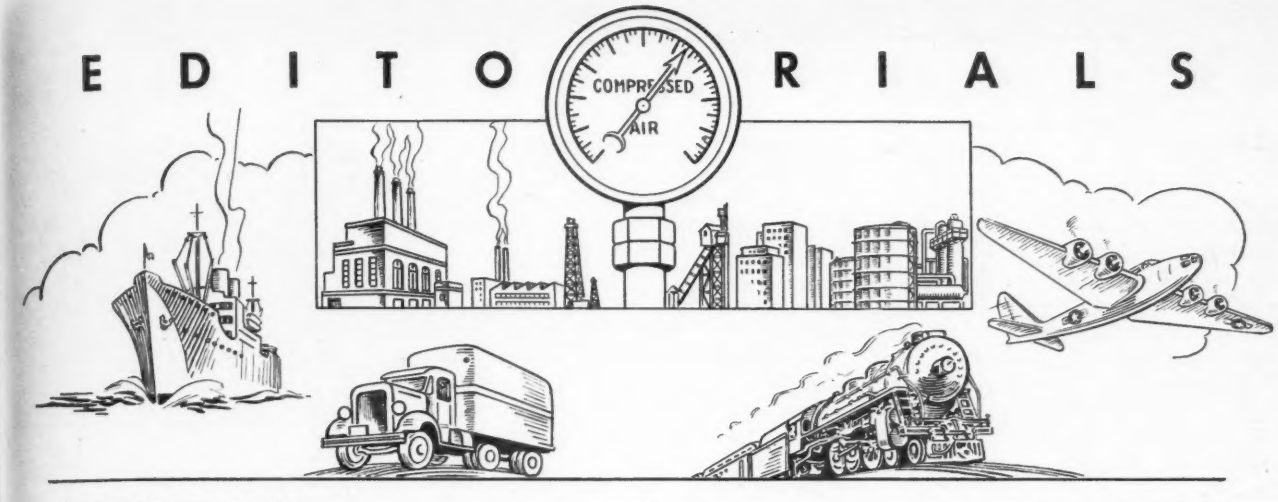
Style of Cylinder	Bore of Cylinder in Inches	Stroke of Piston in Inches	Cubic Feet of Free Air Per Operation 80 Pounds Pressure	Power in Pounds 80 Pounds Pressure
Single Acting.....	6½	1¼	.1352	2184
Single Acting.....	8	1¼	.2300	3639
Double Acting....	3	1⅛	.0315	565
Double Acting....	4	1⅛	.0558	1005
Double Acting....	5½	1¼	.1153	1904
Double Acting....	6½	1¼	.1352	2564
Double Acting....	8	1¼	.2300	3952
Double Acting....	10	1¼	.3460	6120
Double Acting....	12	1¼	.5022	9048

Leakproof Castings for Airplanes

MAGNESIUM, aluminum, and other metal castings enter largely into the manufacture of airplanes, but before they can be used must be impregnated with a sealing compound because they have a tendency to be porous. This applies especially to the parts of high-compression engines whose function it is to hold gasoline, oil, and solvents. To make them leakproof, they are subjected to the vacuum-pressure method by which the contained air is withdrawn by vacuum and the voids are filled with a viscous fluid with compressed air.

Liquids such as tung oil were formerly used for the purpose, but when they became scarce it was necessary to provide substitutes. One of these is a mixture of synthetic resin and monomeric styrene that is said to be nonvolatile and actually superior to the substances it has supplanted. It is a product of the Ault & Wiborg Division of the Interchemical Corporation and is applied in varying proportions: 60 parts of styrene and 40 of resin for small pores; 40 of styrene and 60 of resin for large openings; and a 50-50 mix for the general run of requirements. After impregnation, the sealing compound on the outer surfaces is removed by standard industrial cleaners and that in the pores is polymerized by baking the castings under pressure for two hours at a temperature of 250-275°F.

EDITORIALS



WHAT LIES AHEAD

THE newspapers and magazines are filled with postwar plans, and probably only a small proportion of those advanced receive much publicity. It is obvious that all cannot be put into effect, and it is well that this is so, for many of them are undoubtedly crackpot schemes. Nevertheless, all this contriving augurs favorably for the future. It indicates that many persons are aware that our country, in common with others, will face problems of unprecedented magnitude as soon as the shooting stops. Only the jungle peoples, the Eskimos, and others in outlying areas will escape the impact of the economic disruption that impends. These primitives know neither the blessings nor the curses of the regimentation that we call civilization. War or no war, they will continue to take their living from the land and the sea, as did their forefathers. Perhaps they are fortunate, yet few of us would care to exchange places with them. Anyway, we couldn't if we wanted to, so we must try to find a way out of the difficulties into which world events have maneuvered us.

It is a tough situation, to say the least, and it is well that so many brains, including some of the best, are seeking a path that will lead us out in the open and not deeper into the woods. We must not only discover the right path but we must also have the good sense to choose it instead of the hundreds of others that we might take. And, once we are on it, we must be able to follow it. It will not be straight, nor short, nor well marked, and there will be many branches, with a chance of going astray each time we come to a junction.

No matter what kind of a brush we use, the years ahead make a dark picture, but it is not wholly lacking in light spots. Great problems make great leaders, and America still is a strong country made up of strong people. We are not facing our difficulties with complacency, nor with foreboding, but are calmly and resolutely setting about the charting of a course, knowing full well that the task is not an easy one. Out of all the proposals that are being and will be offered, the solution will be sifted. That is the way a democracy works.

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THE SAGA OF A FREIGHTER

SEVERAL recent articles in these pages have dealt with the use of compressed air in the salvage of ships. One of them described the rehabilitation of the fleet at Pearl Harbor, and another the raising of the ex-liner *Normandie*. Examples such as these that reach public attention are few compared with the hundreds of instances of crippled or sunken craft that have been and are being put back into commission without any publicity. Many of the recoveries are purely workaday jobs; others would make thrilling stories if they could be told. And now and then one is released, such as that of the Liberty Ship *James W. Marshall* that was rescued from a briny graveyard after having been bombed at Salerno, Italy, last September.

Following an attack by a German fighter plane that wounded four of her crew, an enemy bomber dived out of the clouds and scored a direct hit, the missile penetrating the deck and exploding in the crowded crew's mess, killing thirteen seamen and several soldiers and starting a fire that spread rapidly. As the ship settled, the captain ordered her abandoned. However, she refused to sink, and as she carried cargo that was badly needed on the beachhead, she was reboarded by a party under Capt. J. M. Wainright IV, son of the general who held out to the last at Corregidor.

With 30 feet of water in the engine room, Captain Wainright and nine volunteers labored nine days to get the bodies ashore and to unload the cargo. Then, with air compressors running to keep more water from entering the vessel, she was towed by another Liberty Ship to Bizerte, Africa, for temporary repairs. There it was realized that she would have to be sent to England for a complete overhaul. Her condition was such as to make this a perilous journey; but 31 merchant seamen, whose freighters had been sunk, volunteered to make the attempt. The engine room was pumped out and the *James W. Marshall* made the designated English port under her own steam.

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WAR AIDS PRISONERS

TO FIND a class of people that has benefited from the war we can, strangely enough, look behind prison bars. War-production training classes conducted in a score of our penal institutions have prepared hundreds of the inmates for useful and remunerative jobs, and they are being hired as fast as they are released.

New York, California, North Carolina, and Ohio are leading in this work in their state penitentiaries. New York alone has six schools. In Federal prisons, also, intensive ten weeks' courses are teaching men and women the art of welding, wood and metalworking, and other skills. Over a period of six months, Atlanta, Ga., has placed 276 of her former convicts in essential war jobs, and only a dozen of them have failed to make good. From San Quentin, Calif., state penitentiary come cooks and bakers many of whom are employed on United States cargo ships. North Carolina has enabled 250 prisoners to take jobs mostly in shipyards. All told, about 3300 men and women have received instructions in specific types of work.

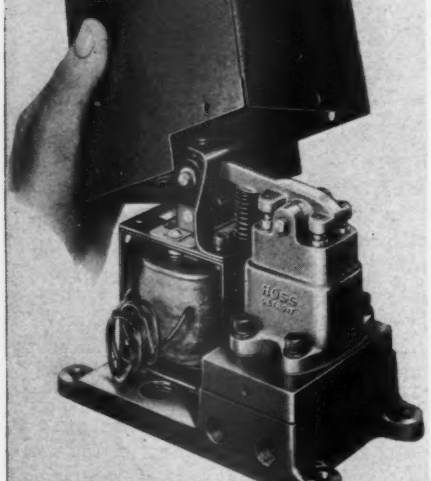
The classes are made up of selected inmates who are freed on parole at the end of the training period. When they are considered capable of holding jobs, they are placed with companies doing war work. They receive prevailing wages. Most of the prisons in which these vocational courses are being taught were already well equipped with shops and regularly conducted "long-time" training programs. In other instances, the Federal Government has assisted in purchasing needed facilities.

Industrial Notes

A 3-inch layer of expanded vermiculite is said to have the insulating value of a 5-foot brick wall or a 7-foot concrete wall.

Zinc-coated steel strip and sheets are being offered by the Weirton Steel Company in widths of from ⅜ to 38 inches and of steel ranging in gauge from 0.008 to 0.037 inch, or 39 to 21 based on zinc gauge. It is produced by the same electrolytic equipment used by the company for tin-plating and has many applications, including the manufacture of flexible hose, builders' hardware, and furniture.

Ross Operating Valve Company is offering a noiseless poppet-type air-control valve of midget size that can be operated, it is claimed, at sustained speeds up



to 400 reversals per minute. It is known as Model No. 835 and is a ¼-inch, heavy-duty, solenoid, 4-way valve for double-acting pneumatic cylinders. It can also be made to serve as a 3-way valve by plugging one outlet. The unit is 7 inches long, 3½ inches wide, and 5¼ inches high.

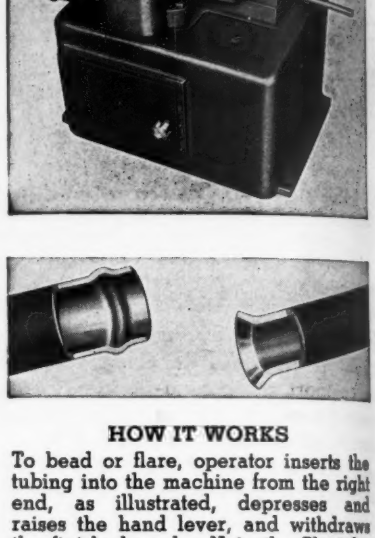
According to findings recently made public by the National Bureau of Standards, an above-average grade of galvanized-steel wire used in a region like Pennsylvania loses approximately one-third of its protective zinc coating in about six years. This means that a fence made of such wire will not show evidence of severe corrosive damage under normal atmospheric conditions for from 18 to 20 years.

Magnaflux Corporation, 5906 Northwest Highway, Chicago 31, Ill., has prepared an orange dye for application to metal parts that are too small to be stamped or etched to signify that they have passed Magnaflux, Magnaglo, or Zyglo inspection. The liquid dries hard in half a minute and meets Army-Navy aeronautical requirements. A sample may be obtained upon request.

Steeltem Chemical Company has announced a new steel-hardening solution as a companion product of Steel-Temp. The latest solution is called Super-Temp and is intended for quenching friction wearing parts and high-speed steel tools that operate with a uniform or rotary motion. It is not adapted for impact tools because the resultant superhardness is obtained at a sacrifice in toughness. Immersion both hardens and draws the metal, making it highly resistant, it is claimed, to friction and abrasion and minimizing the need for regrinding.

A new corrosion-proofing material that has been put on the market by Insl-X Company for electrical equipment contains a germicide that is said to protect it also against fungi. The solution is applied by brush or spray and dries tack free in about fifteen minutes and hard in an hour. It is said to adhere to various kinds of surfaces and has an effective temperature range of −50°F. to +350°F. The liquid is approved for use under Signal Corps Specification No. 71-2202.

A quick-acting tube beading and flaring machine has been announced by the Vaill Engineering Company. The unit is operated by two air cylinders, one to chuck the tubing and the other to shape it. Both cylinders are actuated by one valve and with compressed air at a line pressure of approximately 80 pounds. The machine handles aluminum as well as lighter-gauge steel, copper, and other workable-metal tubing of all sizes up to and including ¾ inch, outside diameter; and chucking dies and tools can be furnished to bead and flare to AN and



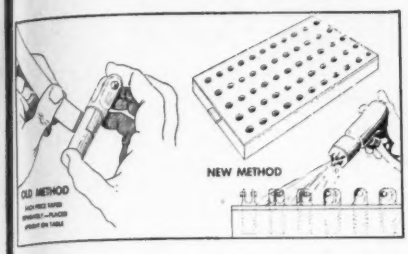
HOW IT WORKS

To bead or flare, operator inserts the tubing into the machine from the right end, as illustrated, depresses and raises the hand lever, and withdraws the finished work. Note the Plexiglas guard with which the moving parts are protected. At the bottom are shown two of the different shapes that can be obtained.

AC specifications. Changeover from one set to another is effected quickly, the tools being stored in a compartment

in the machine itself. It is claimed that the apparatus leaves no score marks on the inside of the tubing and that it can upset more than 600 tube ends an hour.

The accompanying drawing virtually tells its own story and shows a simple



perforated rack of wood that is designed to hold numerous pieces of work that are not to be coated in their entirety. By this method of group masking it is possible for one man to paint three times as many units in a shift as he was able to handle when he had to apply masking paper to each one and to peel it off after the work was dry. It is used in the shops of The Murray Corporation of America.

Coffee, which begins to lose its flavor soon after it is exposed to the air, is prevented from deteriorating by spraying the bean with pure coffee oil. The process was developed by Dr. David S. Isrin, a Russian chemist, and is said to provide an effective seal for about six months.

Plastics, glass, porcelain, wood, cloth, paper, and other nonconductors can, it is claimed, be given high electrical conductivity by coating them with a new compound containing silver powder. It is available in liquid, cement, and other forms to meet different requirements; is applied by spraying, dipping, or brushing; and is either air dried or baked. The resultant surface is of a dull metallic-gray, and aging and exposure to sulphides are said to have only a slight effect upon its conductivity.

Investigation has shown that the organic reagent dithizone can rapidly detect the presence of as little as a few micrograms of copper in a nickel-plating solution. Even a minute quantity of copper in such a bath will cause the nickel plate to darken and make it brittle. This subject was covered in detail in a paper, entitled *Rapid Determination of Copper in Nickel-Plating Baths*, presented at the annual meeting of the American Electroplaters Society by Dr. B. B. Knapp, chemist of The International Nickel Company, Inc.

Designed for toolroom use, George Scherr Company, Inc., is offering a glass plate for the precise gauging of height and of parallel, straight, square, and flat surfaces. It is made of Pyrex-brand glass that is ground and polished optically flat to 0.00005 inch. There are two sizes: one 12 inches in diameter and 2 inches thick and the other 16x3 inches. The plate is known as Opti-Flat.

A combination wood-and-steel tie for mine use is being manufactured by the Wood Preserving Division of the Koppers Company. Its base is of preformed, prebored oak impregnated with creosote by the pressure method and is 2, 3, or 4 inches thick to meet different haulage requirements. Fastened to it by special bolts and nuts is a Bethlehem Steel mine tie of the required size. The unit is furnished with outside stationary clips or, for curved rail sections, with staggered clips. Known as Ar-Moored ties, they can be quickly recovered and relaid without bending, distortion, or "spike-kill." Further claims made for them are that they maintain track gauge permanently; that they materially reduce installation costs; and that they have an average life of 8 to 20 years, depending upon the character of the service.

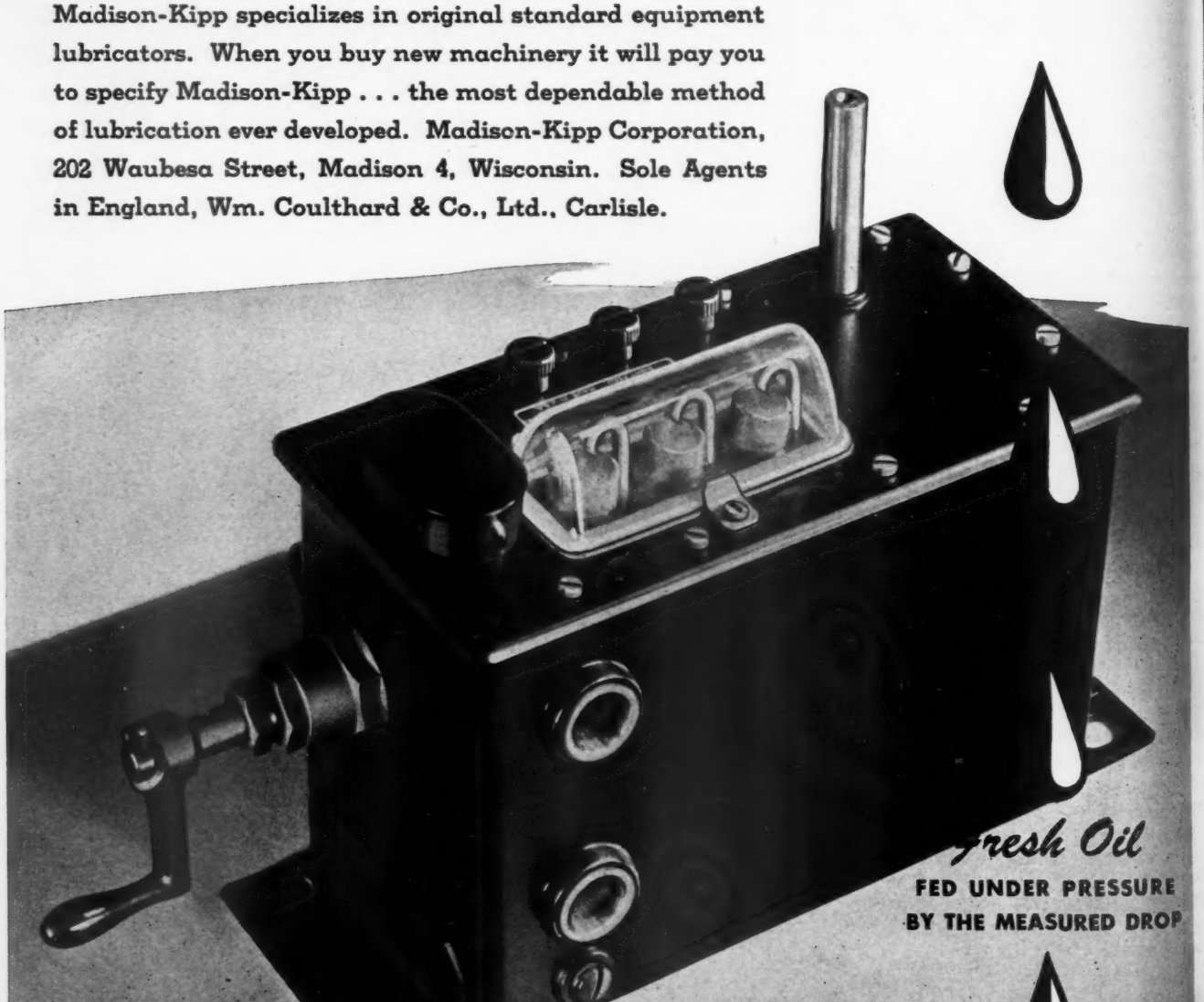
Scrap salvage, reclamation of small tools, conservation of tires on industrial cars, and the safety of workers are the reasons back of the magnetic floor sweeper for factory use developed by Stearns Magnetic Manufacturing Company. The unit is light in weight for easy handling and consists of a permanently magnetized drum that presents an 18-inch face as it is pushed along. It picks up nails, screws, washers, rivets, magnetic chips, etc., and deposits them in a removable tray.

MADISON-KIPP

Fresh Oil

LUBRICATORS

There are Madison-Kipp lubricator models for every Fresh Oil application. There are 6 models and each can be varied to suit the requirements in drive type and location, in the number of feed outlets, rate of feed and pumping pressure. Madison-Kipp specializes in original standard equipment lubricators. When you buy new machinery it will pay you to specify Madison-Kipp . . . the most dependable method of lubrication ever developed. Madison-Kipp Corporation, 202 Waubesa Street, Madison 4, Wisconsin. Sole Agents in England, Wm. Coulthard & Co., Ltd., Carlisle.



THE MOST DEPENDABLE METHOD OF LUBRICATION EVER DEVELOPED

Guessing and gazing are out when it comes to buying your flow control equipment. Because, for even the simplest operation, the valve must be of correct design to obtain maximum efficiency. This not only includes basic type, such as Globe, Angle, Gate, "Y", Check, etc., but such factors as suitable stem action, bonnet construction, working pressure and also the materials used in the body and mountings.

Powell Engineering has developed a complete line of valves especially adapted for controlling the flow of compressed air. The valves shown here are examples of the Powell line of iron body, bronze mounted valves of all types.

And to assist you in selecting the correct valves for your individual requirements, Powell Engineering is always at your service for consultation and advice.

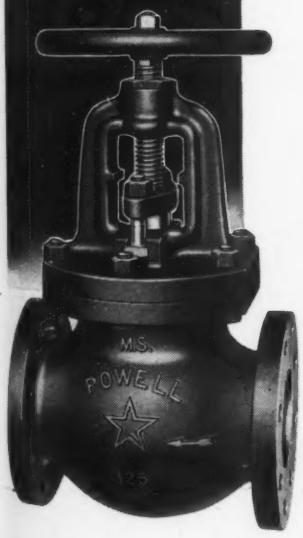


Fig. 241—Iron Body Bronze Mounted Globe Valve for 125 pounds W. S. P. Has flanged ends, outside screw rising stem, bolted flanged yoke bonnet and regrindable, renewable bronze seat and disc.

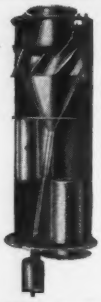
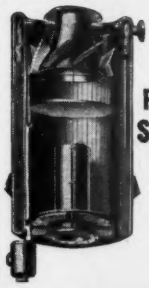
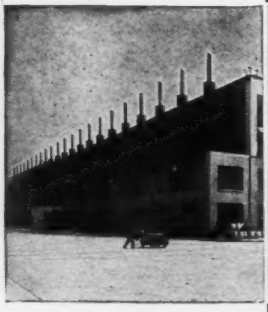
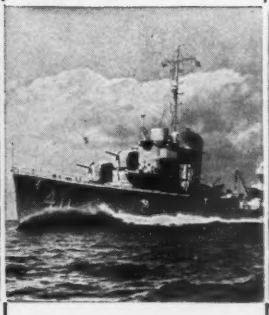
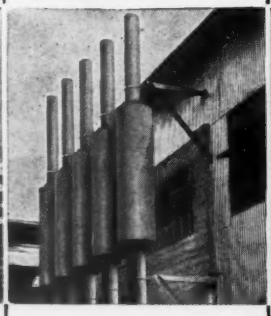
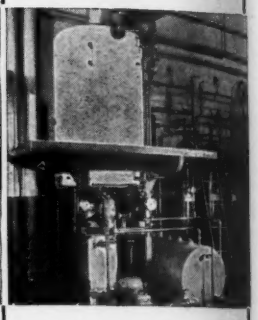
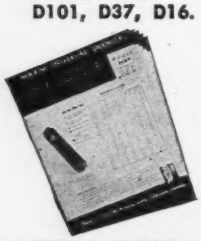
Fig. 1793—Large size Iron Body Bronze Mounted Gate Valve for 125 pounds W. S. P. Has flanged ends, outside screw rising stem, bolted flanged yoke and taper wedge solid disc. Sizes, 2" to 30", inclusive. Also available with taper wedge double disc. — Fig. 1444.

The Wm. Powell Co.

Dependable Valves Since 1846

Cincinnati 22, Ohio

POWELL VALVES

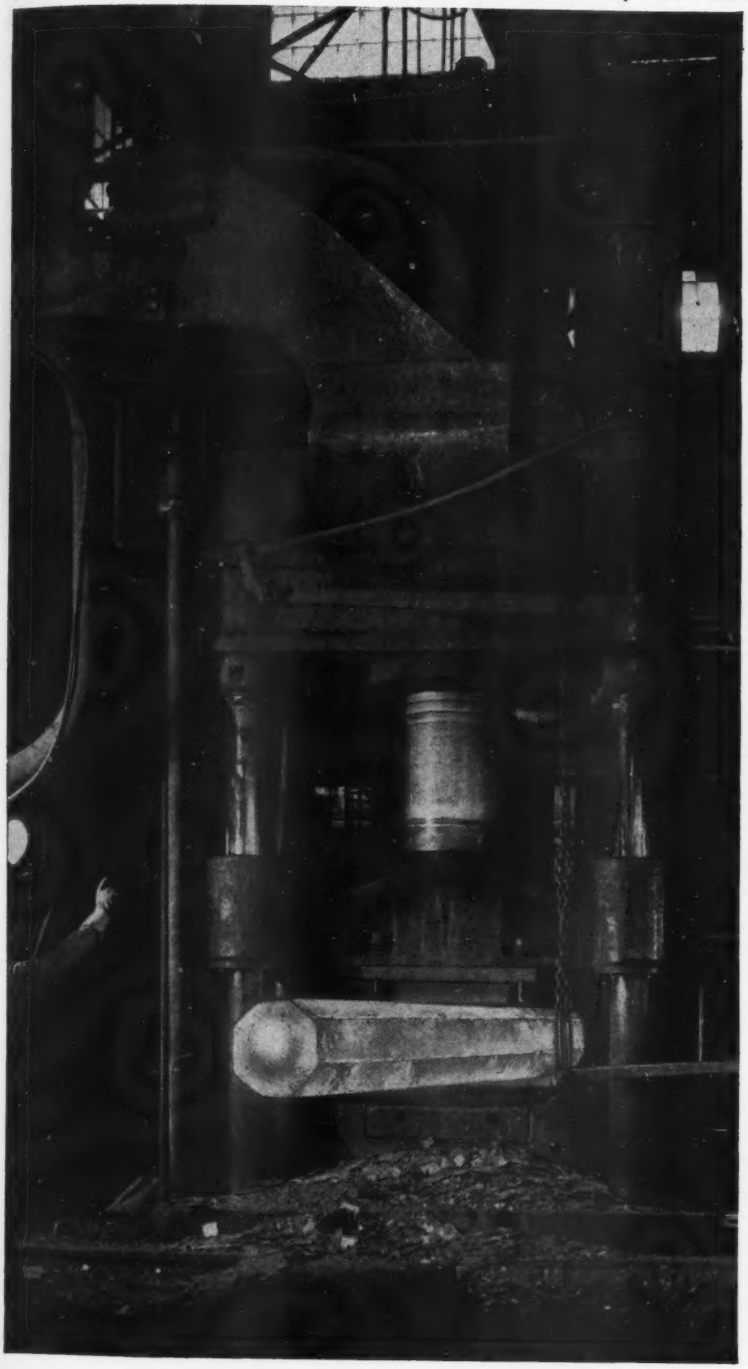
	EXHAUST AND INTAKE SILENCERS	SPARK ARRESTOR SILENCERS	STEAM BLOW-OFF SILENCERS	HEAT RECOVERY SILENCERS
WHAT				
WHERE				
WHEN	● These Maxim Silencers are designed to silence the exhaust or intake of internal combustion engines, steam engine exhausts, air compressor intakes, vacuum pump discharge and the intake or discharge of blowers of the positive pressure type. Wide choice of models to fit varying space and silencing requirements.	● Maxim Spark Arrestor Silencers effectively silence exhaust noise and in addition provide for 100% trapping of all sparks and embers which might come from the exhaust. Of obvious value in marine use, these Spark Arrestors are also applicable to industrial use where a fire hazard exists.	● These silencers were developed for use on installations involving the discharge of high velocity steam, air or gas to atmosphere. Used for steam blow-off, safety valve discharges, etc. Silencers shown above installed on high velocity steam exhaust have a total capacity of 135,000 lbs. per hour.	● Maxim Heat Recovery Silencers combine efficient silencing of engine exhaust with spark arresting (where necessary) and with the recovery of waste exhaust heat to produce steam or hot water. Highly efficient heat transfer . . . automatic controls . . . may be run wet or dry.
HOW	**BULLETINS: D125, D127, D101, D37, D16.** 	**BULLETINS: D105 and D33.** 	**BULLETIN: D111.** 	**BULLETINS: WH100, WH101 and WH103.** 

THE MAXIM SILENCER CO. - 85 Homestead Ave., Hartford 5, Conn.

ARMY E NAVY

MAXIM

IF THE FORGING IS HEAVY DUTY, IT SHOULD BE NATIONAL FORGED



Working the steel ingot not only requires tremendous pressure but an expert knowledge of steel forging gained by years of experience.

The Smiths of yesterday

ARE THE

FORGESMITHS OF TODAY

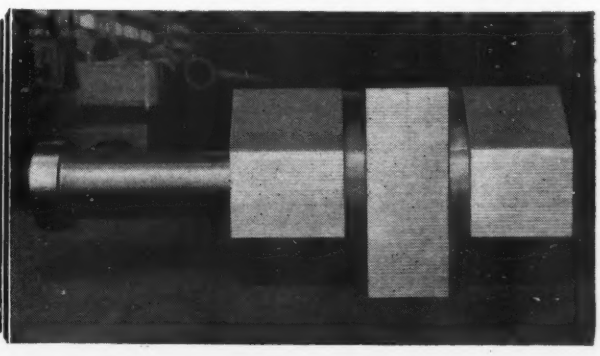
BUT what a difference! The brawny arm that stroked the cherry red bar on the sombre anvil, now is a huge hydraulic press that irresistibly squeezes a large ingot of alloy steel into its desired length, breadth and thickness.

And the manner of that squeeze, as well as the pre-heating of the ingot and the speed of the forging press, will have a determining influence on the structure and flow of the grain in the final forging.

It is no wonder then that the long acquired skill of the forgesmiths at National Forge, as well as the facilities with which they work, count so much in the inherent quality of National Forgings.

But remember, too, that the high regard National Forgings have earned in the heavy duty field is due also to the quality of the steel as National Forge makes it, the thoroughness of the heat treatment, and the high precision standards of the final machining. Whenever you have a steel forging to plan and purchase, let National Forge advise you on all the forging factors involved in making a forging that will fulfill its mission in a creditable manner.

This Compressor Cylinder must be forged with the skill and care to enable it to withstand high internal working pressures.



NATIONAL FORGE & ORDNANCE CO.

IRVINE, WARREN COUNTY, PENNA.

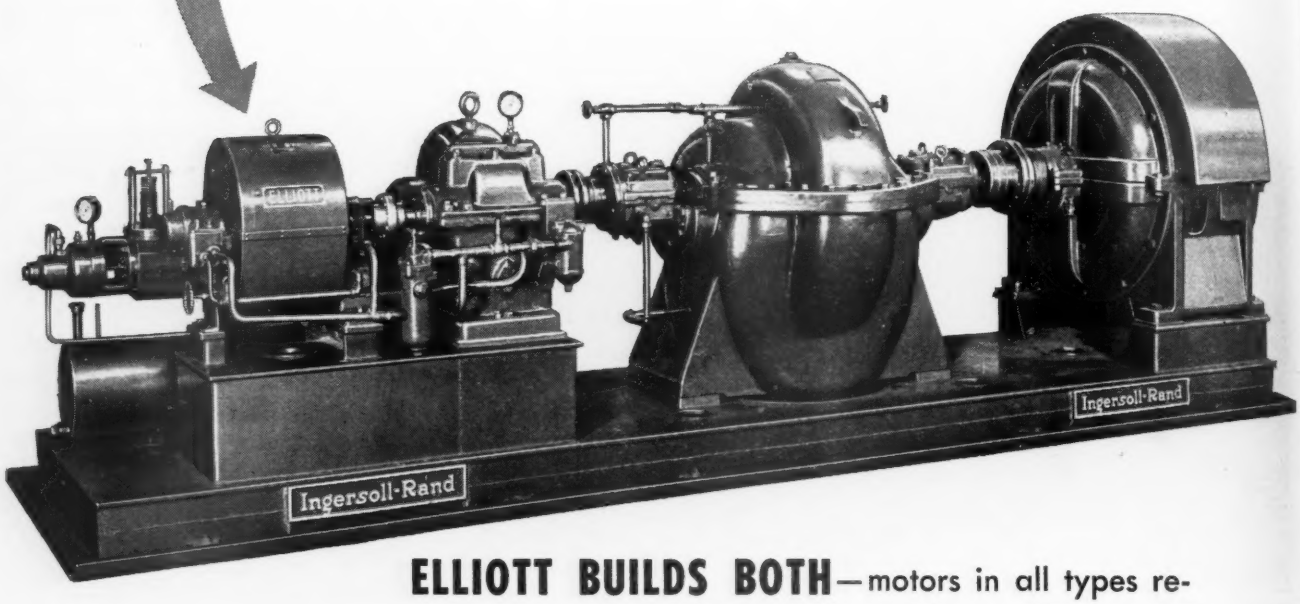
"WE MAKE OUR OWN STEEL"

For Excellence E *in Production*

☆ ☆ ☆ ☆

TURBINE or MOTOR

for your pump drives?



ELLIOTT BUILDS BOTH—motors in all types required for power plant auxiliary drives, with especial emphasis on two-pole, 3600-r.p.m. units. Turbines in single-stage or multi-stage, with or without speed reduction gears. The dual drive unit pictured is representative, being so arranged that electric power failure, reducing the r.p.m., would automatically open the turbine governor valve and bring the turbine into action.

Elliott auxiliary drive units, because of characteristically Elliott conservative design and emphasis on fine materials and workmanship, have extra performance built into them.

Whether it's turbine, motor, or dual drive, make it Elliott for assured performance.

ELLIOTT COMPANY
JEANNETTE, PA. • RIDGWAY, PA. • SPRINGFIELD, OHIO
DISTRICT OFFICES IN PRINCIPAL CITIES

Q-1112

ELLIOTT Company

STEAM TURBINES • GENERATORS • MOTORS • CONDENSERS
FEEDWATER HEATERS AND DEAERATORS • STEAM JET EJECTORS
CENTRIFUGAL BLOWERS • TURBOCHARGERS FOR DIESEL ENGINES
TUBE CLEANERS • STRAINERS • DESUPERHEATERS • FILTERS

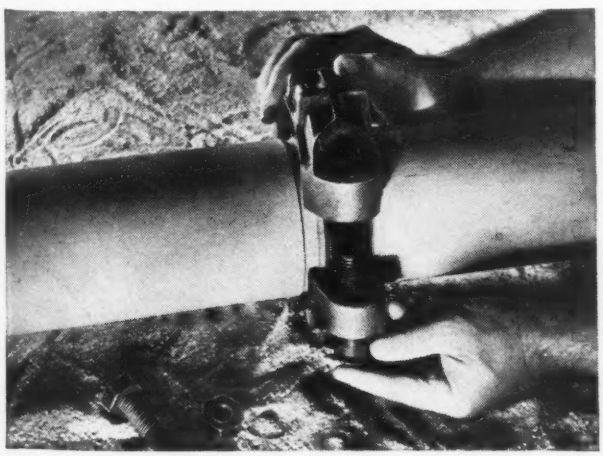
How to make a Leak-tight Pipe Joint . . . FAST!

There's one sure way that eliminates all guesswork. It takes no special skill or training. It calls for no special equipment . . . only one small wrench is required. All you need is standard grooved pipe . . . and Victaulic Couplings. Here's what you do . . .

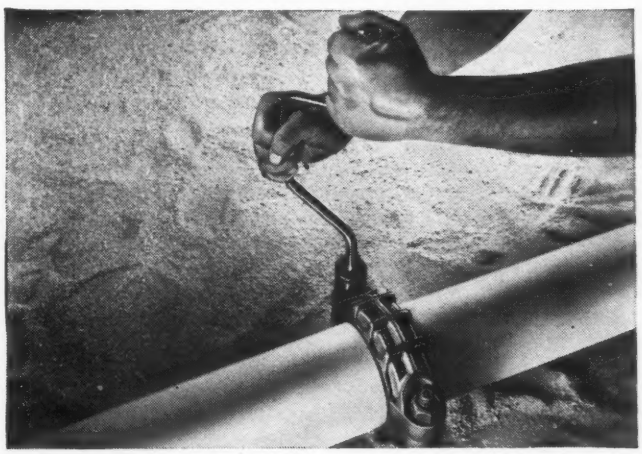
1 Your Victaulic Coupling is simple, fool-proof . . . a single gasket, two half-housings and two bolts only. Spread 'em out.

2 Slip gasket over one pipe and bring pipe ends together. (Don't worry about accurate alignment . . . the Victaulic Coupling permits angular deflection.)

3 Slide gasket into central position over pipe ends. (You're working up to a leak-tight self-sealing joint...for either pressure or vacuum.)



4 Put on housings and insert bolts. You'll be surprised how little time you've taken until now.



5 Turn down the nuts until housings come together. That's all there is! And at each joint you have flexibility, expansion, a union, and a sure, safe lock . . . faster than you'd have thought possible!

BUY MORE WAR BONDS

VICTAULIC

Reg. U. S. Pat. Off.

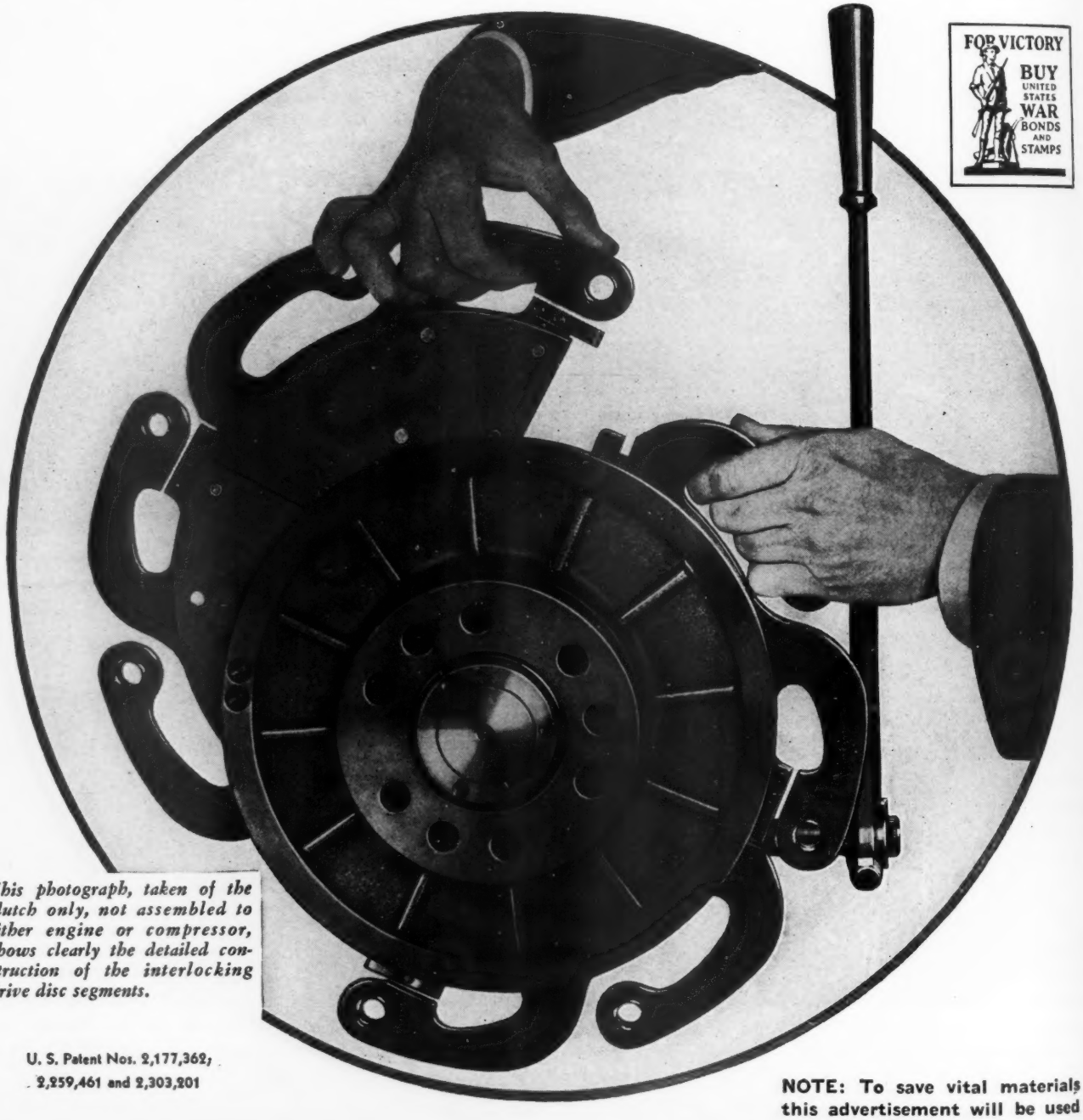
SELF-ALIGNING PIPE COUPLINGS AND FULL-FLOW FITTINGS

NEW VICTAULIC CATALOG MANUAL

. . . a must for every firm that uses pipe. Contains all you need know about Victaulic Couplings and Full-Flow Fittings. Write to nearest address for your copy today on your firm's letterhead. Victaulic Company of America, 30 Rockefeller Plaza, New York 20, N. Y.; Victaulic Inc., 727 West 7th St., Los Angeles 14, Calif.; Victaulic Co. of Canada, Ltd., 200 Bay Street, Toronto.

FLEX-DISC CLUTCHES

Used on the entire line of I-R *Mobil-Air* Compressors, have a time proven drive disc with flexible fingers solidly bolted to the fly wheel. When the friction facings become worn these drive discs, which are quickly detachable in segments, may be removed and relined or replaced without disconnecting the engine from the compressor.



This photograph, taken of the clutch only, not assembled to either engine or compressor, shows clearly the detailed construction of the interlocking drive disc segments.

U. S. Patent Nos. 2,177,362; 2,259,461 and 2,303,201

NOTE: To save vital materials this advertisement will be used for "the duration."

C. M. EASON, INDUSTRIAL CLUTCH CO.

Waukesha Wisconsin

FIT THE VALVE TO THE SERVICE

WALWORTH

Steeliron

LUBRICATED PLUG VALVES

No. 1796 — SCREWED
No. 1797F — FLANGED

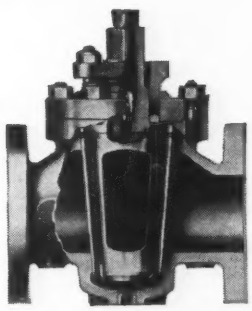
No. 1796

for working pressures up to 175 lbs. O.W.G.

This Walworth lubricated plug valve meets a wide range of requirements, and also helps to conserve critical copper. Made of close-grained, high strength cast iron, it uses insoluble lubricants to assure tight-sealing, easy operation, and resistance to corrosion and wear. This valve is made in sizes from 1″ to 4″, with screwed or flanged ends.

Other Walworth Lubricated Plug Valves are made in sizes from 1/2″ to 24″, for pressures from 125 to 5,000 psi., and for vacuum requirements. They are particularly adaptable for control of gritty solutions and many other erosive and corrosive industrial and chemical solutions. For complete information on Walworth Lubricated Plug Valves, write for a free copy of Walworth Circular No. 91.

Walworth also manufactures a complete line of gate, globe and check valves, as well as pipe fittings and pipe wrenches. Walworth Catalog 42 gives detailed information. Write on your company letterhead for a free copy.



Just a turn of the lubricant screw on a Walworth Lubricated Plug Valve forces insoluble lubricant under pressure through a grooving system and down beneath the plug. The lubricant seals the valve against leakage in either open or closed position, reduces friction between plug and body, and helps protect plug and body against contact with corrosive line fluids.

These are some of the features which make Walworth Lubricated Plug Valves ideal for many "difficult" services.

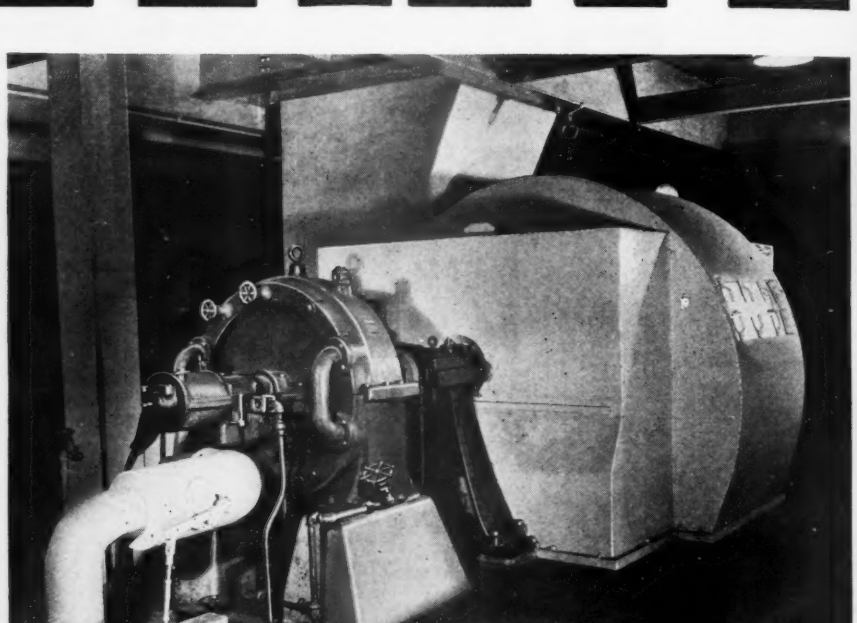
ARMY E ARMY E NAVY

BOSTON WORKS
KEWANEE WORKS

WALWORTH
valves AND fittings
60 EAST 42nd ST., NEW YORK 17, N.Y.

DISTRIBUTORS IN PRINCIPAL CENTERS THROUGHOUT THE WORLD

TERRY



BUCKETS AND ROTOR IN THE TERRY WHEEL TURBINE

. . ALL IN ONE PIECE

In the Terry Turbine the wheel is made from a single forging of special composition steel. The buckets are milled directly in the wheel. There are no parts to become loose or work out. Such construction makes for long life and low maintenance.

This and many other features of Terry Wheel Turbine design are described in our Bulletin S-116. A request on your business letterhead will bring a copy.

ABOVE: 250 H.P. Terry Wheel Turbine driving Induced Draft Fan. Unit is one of ten Terrys installed in a mid-western plant.

T-1153

THE TERRY STEAM TURBINE COMPANY
TERRY SQUARE, HARTFORD, CONN.

80 000 lbs.

ON 8 FULL FLOATING WHEELS

The ceiling on payloads has been raised by Model TR-15T-EASTON's latest development. It is built for hauling heavy material loaded by large shovels in pit and quarry.

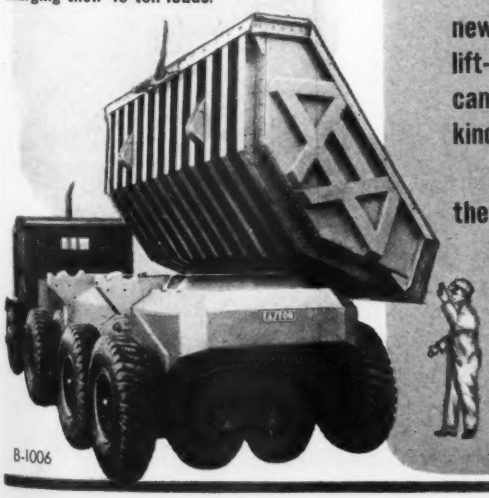
The unique wheel arrangement provides an air brake for each wheel and full-floating, spring-suspension for each dual pair. For the first time, it is now possible to build a semi-trailer of tonnage capacity limited only by the power of the tractor itself.

EASTON engineers have extended the use and application of this new full-floating wheel development to semi-trailers equipped with lift-gate or automatic down-folding door bodies. Quarries and mines can make profitable use of these large tonnage units for handling all kinds of material.

Let us have your haulage problem now! Perhaps we can give you the early delivery you want.

Write to engineering Counsel, Easton Car & Construction Company, Easton, Pa.

The TR-15T is dumped by overhead hoist. Other body models employ hydraulic hoists for discharging their 40-ton loads.



B-1006

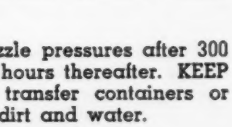
EASTON
INDUSTRIAL CARS
TRUCK BODIES · TRAILERS
ELECTRIC LIFT TRUCKS

Keep Your Horses Pulling on the Victory Road

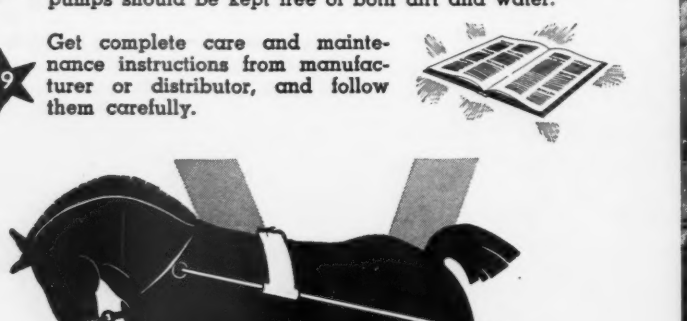
You'll get the most efficient excavator performance when all the "horses" in your engine are pulling full strength. Here are a few hints that may help keep that engine humming.

1. Inspect engine regularly and keep it clean.
2. Warm a cold engine up slowly (don't use choke more than is absolutely necessary).
3. Don't stop a heavily loaded engine abruptly. Let it idle a little to cool off before shutting down.

4. Flush radiator out whenever water gets dirty. Be sure water added is clean. Never add cold water to an overheated engine.
5. Use good grade lubricating oil. (Follow manufacturer's recommendations). Clean sump and change filter element frequently (every other oil change is good practice).
6. Keep proper amount of water in battery. (Add water when starting, never when shutting down). Keep terminals covered with grease to avoid corrosion.
7. In gasoline engine, keep spark plugs and distributor points properly adjusted and clean.
8. In diesel engine, check injection nozzle pressures after 300 hours on a new engine, every 1500 hours thereafter. KEEP FUEL CLEAN. Storage tank and transfer containers or pumps should be kept free of both dirt and water.



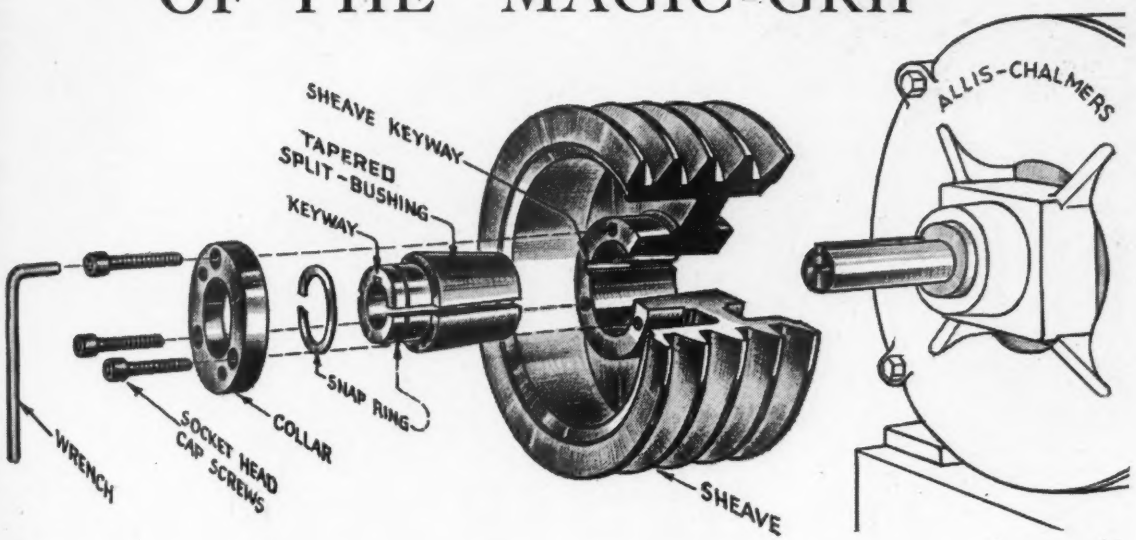
9. Get complete care and maintenance instructions from manufacturer or distributor, and follow them carefully.



Bucyrus-Erie

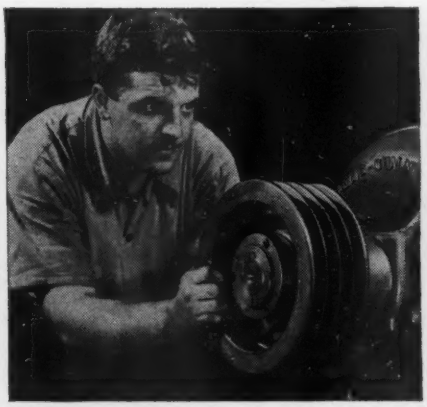
SOUTH MILWAUKEE, WISCONSIN, U. S. A.

Here's the Secret
OF THE "MAGIC-GRIP"



Exploded view shows why Allis-Chalmers' new "Magic-Grip" Sheave goes on *as a unit in 3 easy steps.* It's the fastest mounting sheave on the market—at no extra cost.

1 Place sheave on shaft. Slides on smoothly because clearance is provided by expanded bushing. There's *no* hammering — *no* forcing! Complete sheave and bushing unit comes intact—ready for quick, easy mounting.



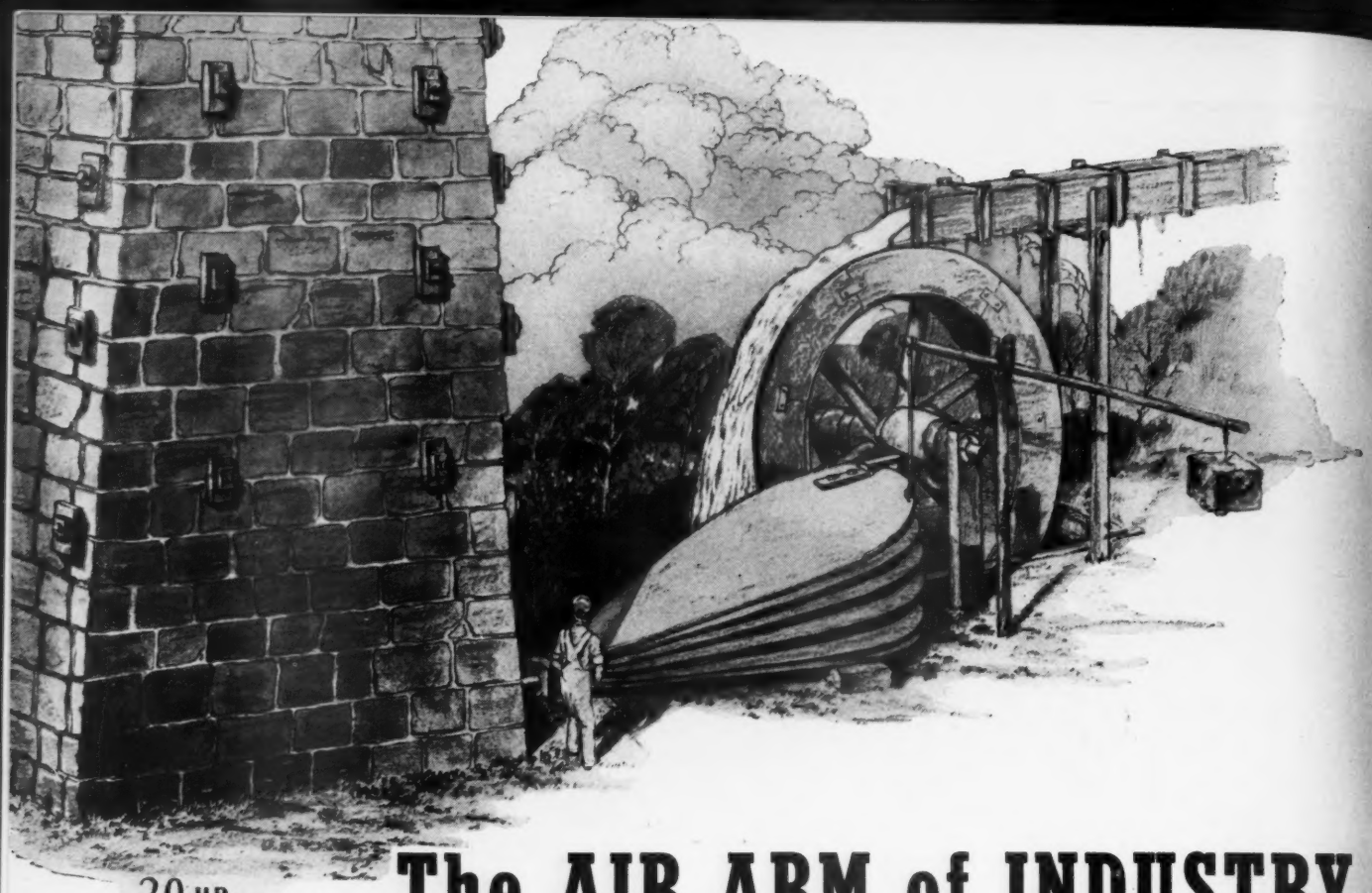
2 Slide to desired position. Sliding easily, sheave can be placed *exactly* according to straight-edge ... giving you true alignment with resulting smooth performance. A minimum of time is required.

3 Tighten three capscrews — and it's ready to go! Entire sheave is locked securely to shaft and *grips like magic!* No set screws to damage shaft. Send for Bulletin B6310. Allis-Chalmers, Milwaukee 1, Wis.

A 1764

Allis-Chalmers Texrope

"MAGIC-GRIP" SHEAVES



20 HP.

Water power converted to air power is illustrated in this artist's drawing based on sketches of a cold blast charcoal furnace worked in the early part of the 19th century. The man standing in front of the bellows gives a proper sense of the plant proportions. (From Two Centuries of Iron Smelting in Pennsylvania by Richard Peters, Jr.).

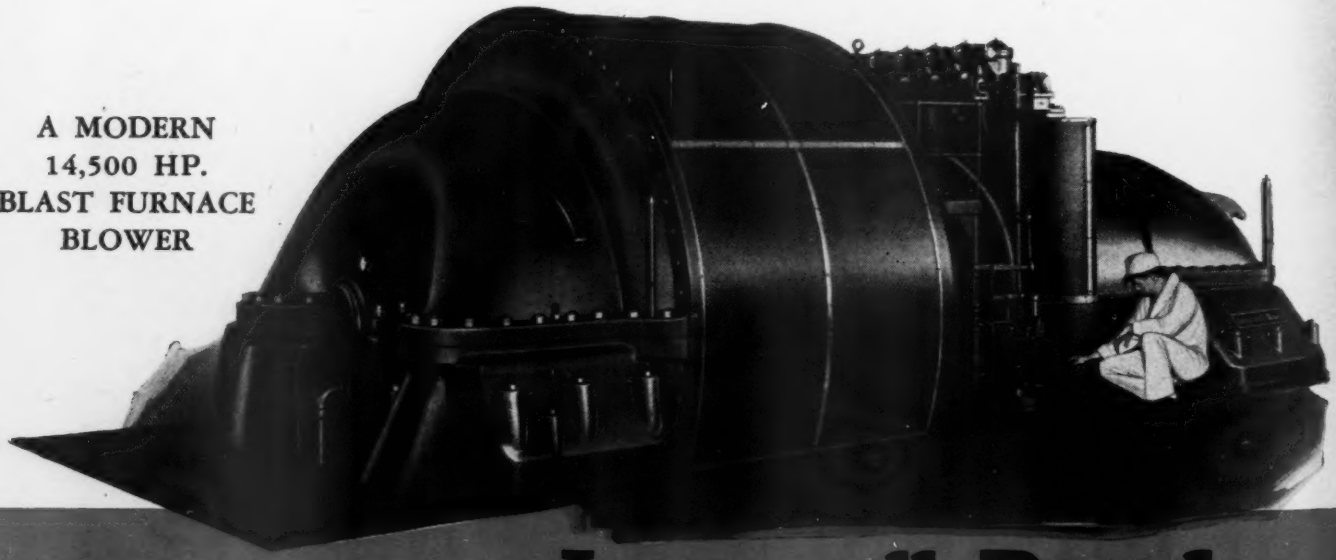
The AIR ARM of INDUSTRY

Since man first blew or fanned a faltering fire, he has been experimenting with compressed air as a means of aiding combustion. The ingenious water-wheel bellows was one of his early efforts—one of many steps toward present day record-breaking production of metals.

Today it is the Turbo Blower that furnishes the air blast. These compact, centrifugal machines compress huge volumes of combustion air for the nation's furnaces and converters. Since 1913, when the first I-R Blast Furnace Turbo Blower was installed, Ingersoll-Rand has maintained its leadership in this field.

Other industries are using thousands of I-R Turbo Blowers for compressing air or gas for a multitude of purposes. Ingersoll-Rand's 30 years' experience in building blowers of all capacities totalling several million horsepower is back of the highly efficient designs available today in sizes of from 2 to 15,000 horsepower.

A MODERN
14,500 HP.
BLAST FURNACE
BLOWER



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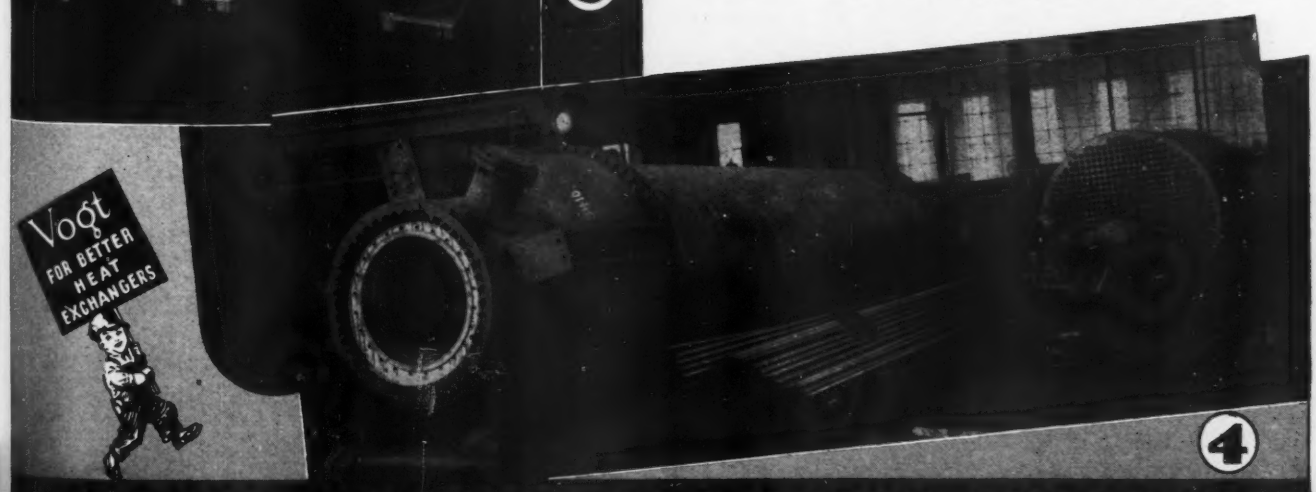
CENTRIFUGAL PUMPS CONDENSERS COMPRESSORS TURBO BLOWERS ROCK DRILLS AIR TOOLS OIL AND GAS ENGINES

In WAR or PEACE it's Vogt for better HEAT TRANSFER EQUIPMENT



1. Heat Exchangers in the foreground have monel metal shells, admiralty metal tubes and naval bronze tube sheets, floating head covers, and baffles. Vogt Ell Bolts are used on floating head covers.

2. Reactors for catalytic polymerization units being assembled and tested. Each is of welded construction and has bolted-on hinged covers.

3. Group of Diesel Oil Exchangers for a visbreaker. Used to exchange heat between diesel oil and corrosive crude containing salt and sulphur compounds.

4. 62″x30′-6″ long Gas Cooler for a catalytic unit in a large refinery. Tube bundle at right is for a second unit.

HENRY VOGT MACHINE COMPANY

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LOUISVILLE, KENTUCKY

Branch Offices: New York, Philadelphia, Cleveland, Chicago, Dallas.

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Marine PRESSURE SWITCHES

DRIPPROOF AND WATERTIGHT HIGH SHOCK CONTACT BLOCK—TWO OR THREE POLE—CLASS 9013 TYPE AW-H, MW-H, LW-H

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Voltage	Single Phase A.C.	Polyphase A.C.	D.C.
110V.	2 H.P.	3 H.P.	1 H.P.
220V.	3 H.P.	5 H.P.	1 H.P.
440-550	5 H.P.	5 H.P.	.....
32V.	.....	.....	½ H.P.

● Built for Marine Service to conform with requirements for dripproof and watertight devices of shockproof construction. The switches differ from standard in the use of a special sheet steel enclosure and drip hood with gasket seal and a special high shock bakelite contact block in two or three pole form. The three types AW-H, MW-H and LW-H represent three diaphragm sizes and three range and differential variations. A release valve for air compressor service may be added to any of the types, as illustrated. Write for Bulletin 562.

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For many years, Compressed Air Data Book and Cameron Hydraulic Data Book have been widely used by engineers in every type of industry. These pocket-sized handbooks are available to the general public through an arrangement with the copyright owner. Now a third book—Cameron Pump Operators' Data joins this set of valuable reference books. All three are handsomely and durably bound, and can be obtained for the new low combination price of $6.00.

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BLOW-BY in a Diesel is a costly waste of fuel. This leakage of compression through the gap openings of ordinary rings past the piston, also breaks down the essential oil film on the cylinder walls which accelerates cylinder and ring wear

For positive and lasting seal of compression, install COOKTITES—they eliminate blow-by because there are no gap openings through which the gas can escape and they continue to function as gapless rings throughout their life.

The ever increasing use of COOKTITES, since their introduction in 1930, is evidence of their success. As one engine builder put it recently " . . . Since installing COOKTITES the engine develops more horsepower than it did when new."

Your Diesel, too, if it is an industrial size engine, will operate much more efficiently after the installation of COOKTITES. Usually, only two COOKTITES per piston will do the trick.

So, in preparing "Specs" to cover orders for replacement rings—or for a new engine—specify COOKTITES.

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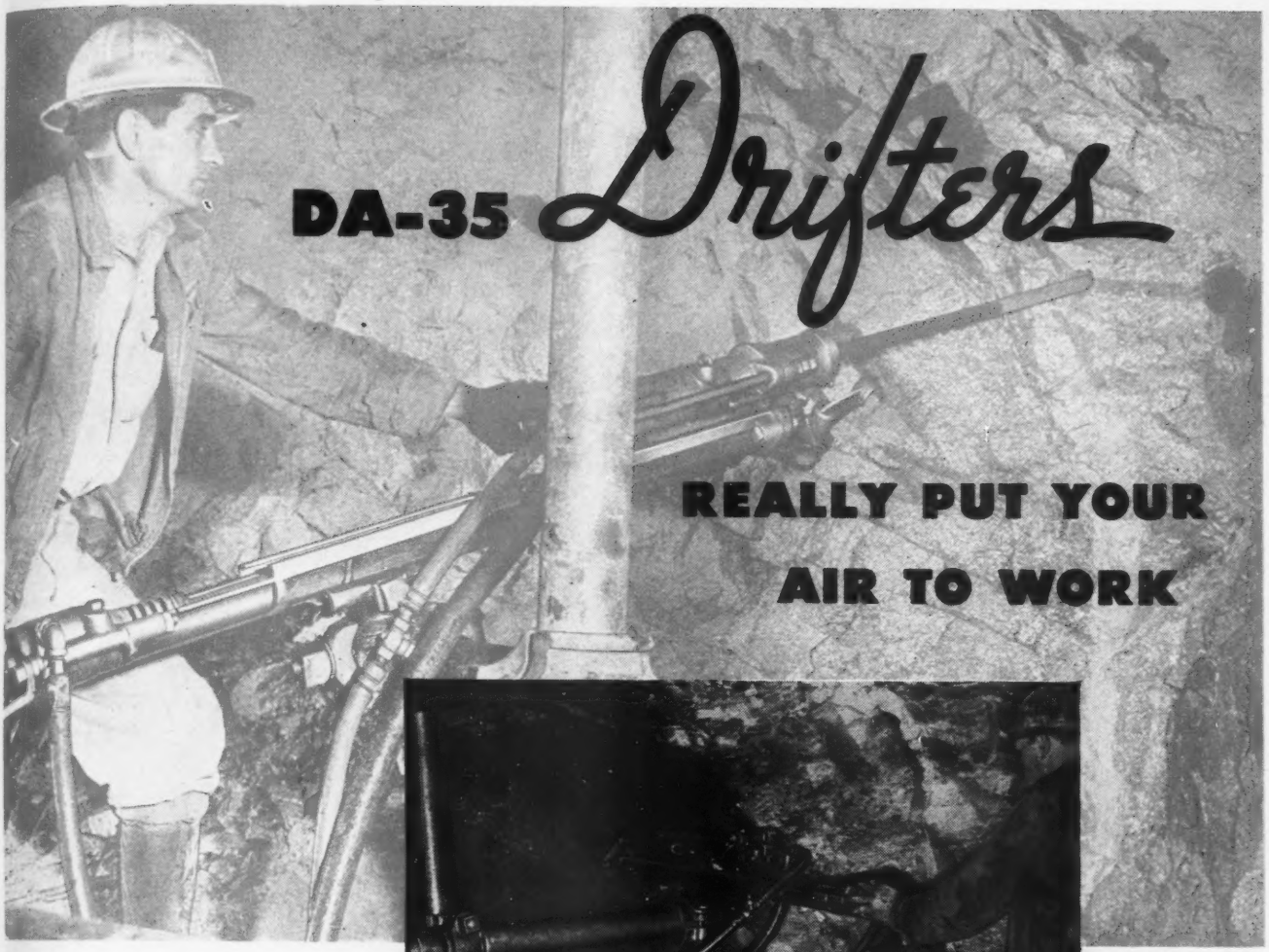
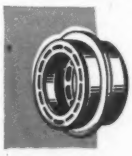


Note the convenient location of the Power-Feed throttle.

Set up a DA-35 Drifter underground. Fasten to it a one-inch air hose and a half-inch water hose. Crack the throttle, collar the hole, then open the DA-35 up wide and watch it eat into the rock. You will see record-breaking drilling speed—speed and durability that recently enabled five DA-35 Drifters to advance a 10-foot bore 1879 feet in one month. You will see performance from a medium-weight, 3½-inch-bore machine that is comparable to that of many, much heavier, 4-inch-bore drifters. Yes, performance that enabled two experienced mining men to report as follows:

"The DA-35 Power-Feed Drifter outdrills our other machines by three holes nearly every shift."

"The DA-35 outdrills our other machines as much as four inches in a 24-inch run."



The highly efficient valving of this outstanding rock drill squeezes every ounce of power out of compressed air and really puts it to work.

Ingersoll-Rand

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COMPRESSORS • TURBO BLOWERS • ROCK DRILLS • AIR TOOLS • OIL AND GAS ENGINES • CONDENSERS • CENTRIFUGAL PUMPS

ANTI-FRICTION PERFORMANCE
is at its best in
TIMKEN BEARING EQUIPPED COMPRESSORS

One of two Ingersoll-Rand 9 x 9 Class ES-1 Booster Compressors installed underground at Empire Mine of Empire-Star Mine Co. Ltd., Grass Valley, Calif.

Anti-friction performance is at its best because Timken Tapered Roller Bearings possess every needed quality. They eliminate friction; prevent wear; carry radial, thrust and combined loads; and hold moving parts in correct and constant alignment.

All these advantages combine to make Timken Bearing Equipped compressors operate smoother; last longer; and cost less for operation and maintenance.

No bearing with less than the Timken Bearing's versatility and endurance can give you the performance you have a right to expect in the anti-frictionized compressors you buy. Make sure you get them. The Timken Roller Bearing Company, Canton 6, Ohio.

TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS

DAYTON V-BELT DISTRIBUTORS WORK WONDERS WITH DRIVES

THE HANDICAP—

An important foundry bought a sand muller for mulling facing sand with sea coal. The machine was built to use a worm gear on a speed reducer, but in the interest of economy and in view of extreme dust conditions in the plant, the engineer hesitated to install this type of drive. He called in the Dayton V-Belt Distributor for a consultation.

THE SOLUTION—

The Dayton Distributor weighed all factors and recommended installation of a Dayton V-Belt Drive — 8 V-Belts, 5" Drive Pulley, 48" Driven Pulley, 66" center to center distance. The Dayton V-Belt Drive has now been performing for nearly four years without requiring a single hour's maintenance time. And the saving over the cost of the other drive amounted to several hundred dollars.

Use This Free, Expert Service to Solve Your Own Drive Problems

You may want to talk to your factory-trained Dayton Distributor about the choice of an original drive, the conversion of old drives, or merely on a matter of maintenance. In any case he will gladly study the problem and make his carefully considered recommendation—without obligation on your part.

In thousands of plants in virtually every industry, Dayton V-Belts are cutting power losses, reducing maintenance costs and equipment tie-ups, increasing production. They run smoothly and quietly, grip firmly and deliver maximum power. Those advantages spring from Dayton Rubber's Technical Excellence in the development of synthetic rubber and 30 years' experience in building V-Belts. You can always depend on Dayton V-Belts for better performance—and on Dayton V-Belt distributors for better service

CALL YOUR DAYTON V-BELT DISTRIBUTOR OR WRITE DIRECT

THE DAYTON RUBBER MFG. CO., DAYTON 1, OHIO

The World's Largest Manufacturer of V-Belts

Dayton Rubber Export Corp., 38 Pearl St., New York, N.Y., U.S.A.

MAINTAIN VICTORY SPEEDS—CONSERVE YOUR TIRES

V-Belts by

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REG. TRADE MARK THE DAYTON RUBBER MFG. CO.

The Mark of Technical Excellence in Synthetic Rubber

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wire rope blocks

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For average work which includes most of the service in industry and construction.

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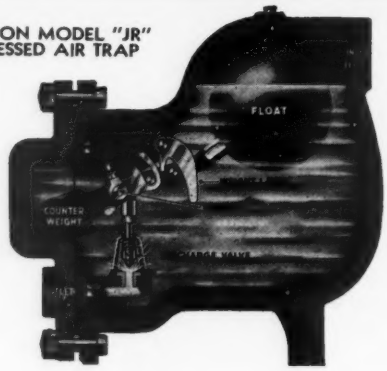
THE GENUINE *Crosby Clip* WHEREVER WIRE ROPE IS FASTENED

NICHOLSON MODEL "JR" COMPRESSED AIR TRAP



Picture of

TROUBLE-SHOOTER No. 1 FOR AIR SYSTEMS

Nicholson Model "JR" Compressed Air Traps are hanging up records for keeping air tanks, receivers, aftercoolers, etc., free from trouble-making collections of water and oil. Pressures to 200 lb:.

BULLETIN 341

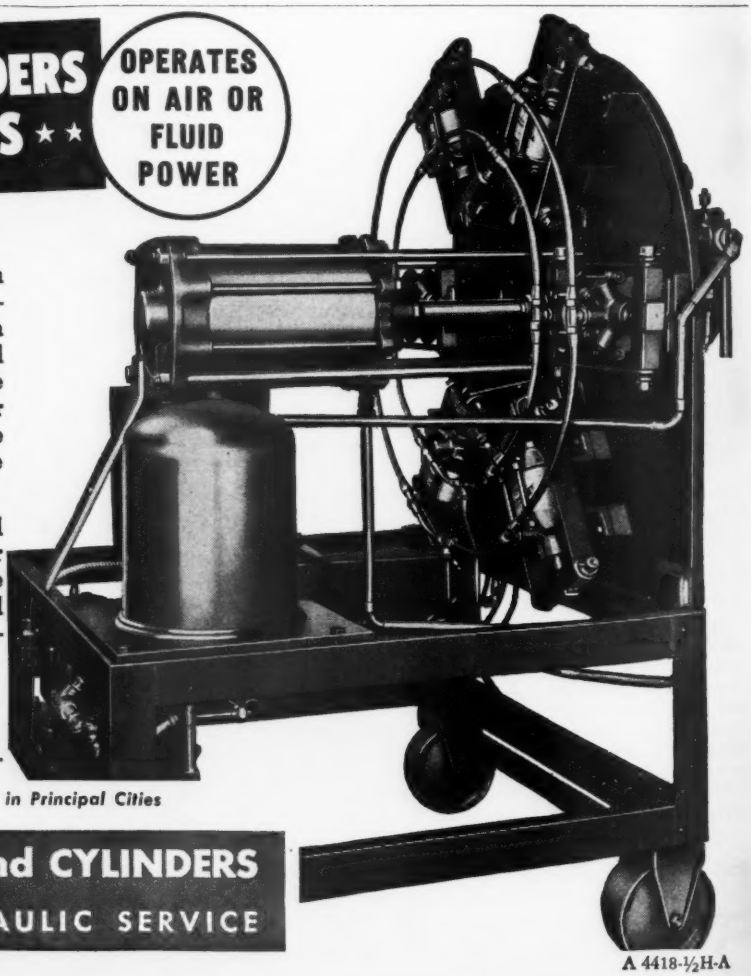
W. H. NICHOLSON & CO.

180 OREGON ST., WILKES-BARRE, PA.

Valves ★ Traps ★ Steam Specialties

Precision WELDING FIXTURE EMPLOYS **7 NOPAK CYLINDERS 2 NOPAK VALVES** ★★

OPERATES ON AIR OR FLUID POWER



This fixture, developed at the Wenthe-Davidson Co., Milwaukee, holds split-ring tubing in position on a cylindrical mandrel while the seam is welded within a tolerance of .003". Six small NOPAK Cylinders, arranged in a circle, actuate lever-clamps which apply equal pressure over the exterior surface of the tubing. The large cylinder operates push rods which eject the finished tube from the mandrel.

One NOPAK 4-Way Valve controls the 6 small cylinders; another controls the large ejector cylinder. This fixture is designed to operate on air or fluid power, at will. A self-contained electrically driven unit quickly generates hydraulic power if air is not available.

For further particulars on this unique example of skillful tool engineering, write for illustrated bulletin.

GALLAND-HENNING MFG. CO., 2759 S. 31st St., Milwaukee 7, Wis.

Representatives in Principal Cities

NOPAK VALVES and CYLINDERS

DESIGNED for AIR or HYDRAULIC SERVICE

A 4418-½H-A

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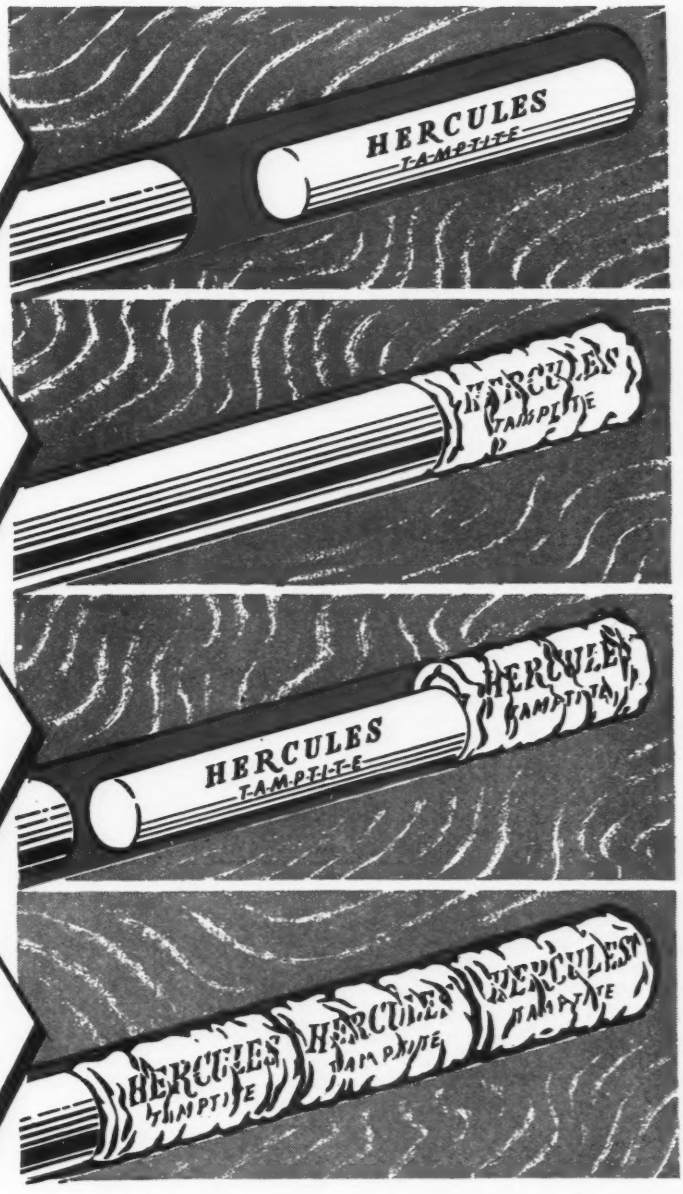
SAVES TIME · SAVES LABOR · PACKS SNUGLY · GIVES BETTER BREAKAGE

1 With Tamptite, you load your favorite Hercules explosive into the bore hole in the usual manner. There's no need to split the cartridge. That saves time and eliminates loose, spilled powder.

2 Next, the tamping rod compresses the dynamite in the hole, packs the charge tightly. There is practically no air space remaining around the charge.

3 Insert another Tamptite cartridge. Then, simply tamp the same as the first cartridge. Continue inserting and tamping cartridges for whatever loading you wish.

4 Your charge is concentrated snugly for maximum blasting effectiveness. The result is better breakage of ore or rock, speedier mucking, and a faster mining cycle.



Order your favorite Hercules explosives in Tamptite cartridges. All the customary grades and sizes of Hercules Gelamites*, Hercomites*, Extra Gelatins, Gelatins, and Extra Dynamites are available in this time-saving wrapper.

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EXPLOSIVES

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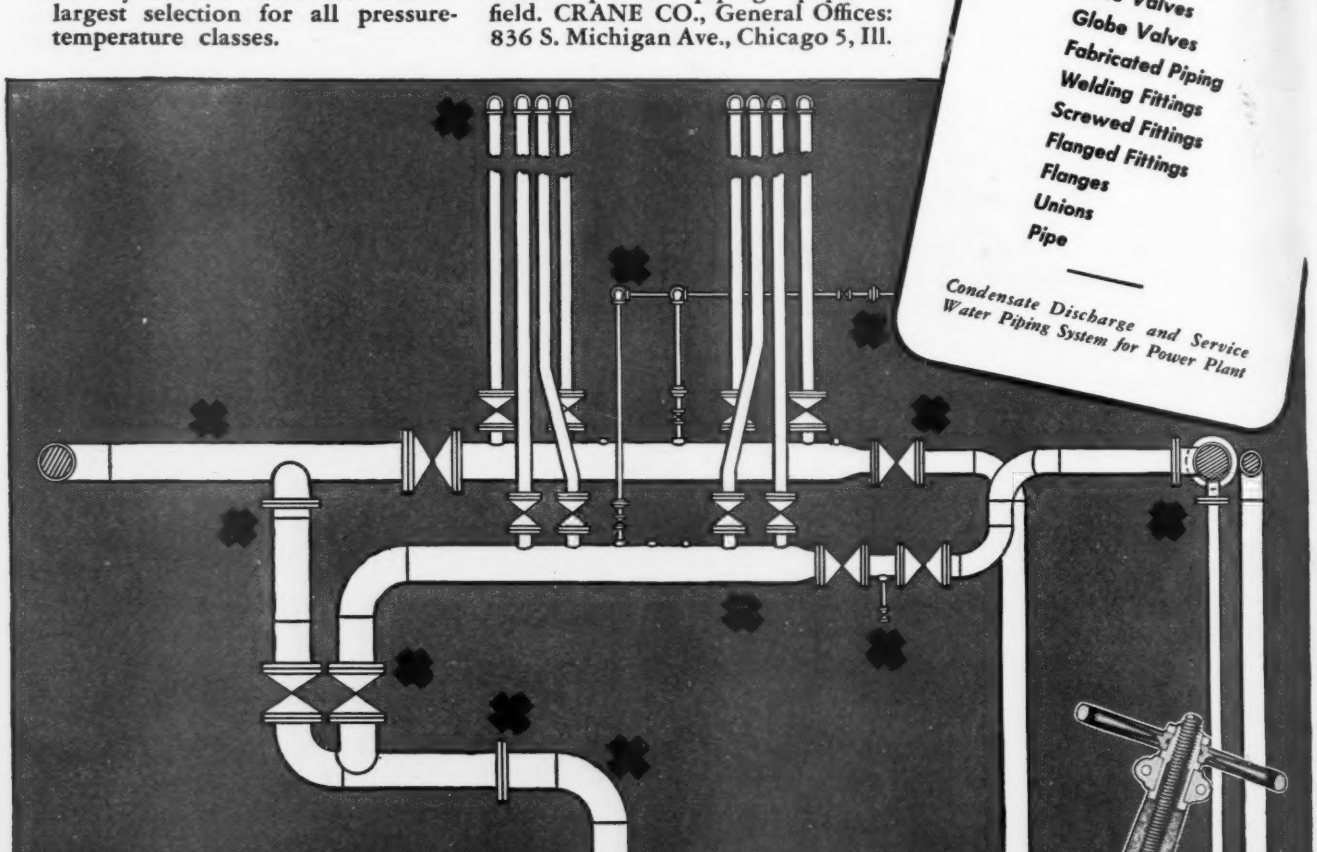
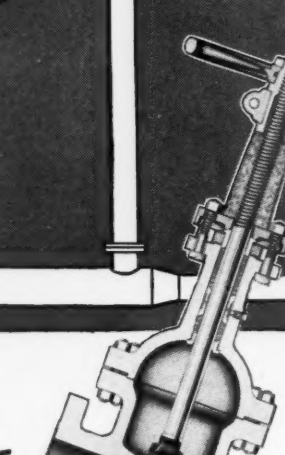
No matter what your needs in piping equipment—whether for power or processing systems—all the benefits of single source supply can be yours. Pipe, fabricated piping, valves, fittings—all these essential materials down to the last accessory are available from Crane. You choose exactly what you need—from the world's largest selection for all pressure-temperature classes.

Ordering—keeping of parts stocks—maintenance—such operations are simplified if you Crane equip. More important, one responsibility for quality and craftsmanship of piping materials is a primary aid to good installation. Crane meets that responsibility with a record of 89 years' leadership in the piping equipment field. CRANE CO., General Offices: 836 S. Michigan Ave., Chicago 5, Ill.



ONE STANDARD OF QUALITY

Equipping completely with Crane materials insures one high standard of quality in every part of piping systems. That dependable quality is exemplified in Crane Steel Gate Valves: Finest flow behavior results from their straight-through ports. Severest line stresses are overcome with rugged bodies. Smooth operation is maintained by a ball-joint type stuffing box gland, strong tee-head disc-stem connection, and ample stem bearings. Positive seating is aided by extra long guide ribs.



CRANE

VALVES • FITTINGS • PIPE
PLUMBING • HEATING • PUMPS

DOSE OF SALT

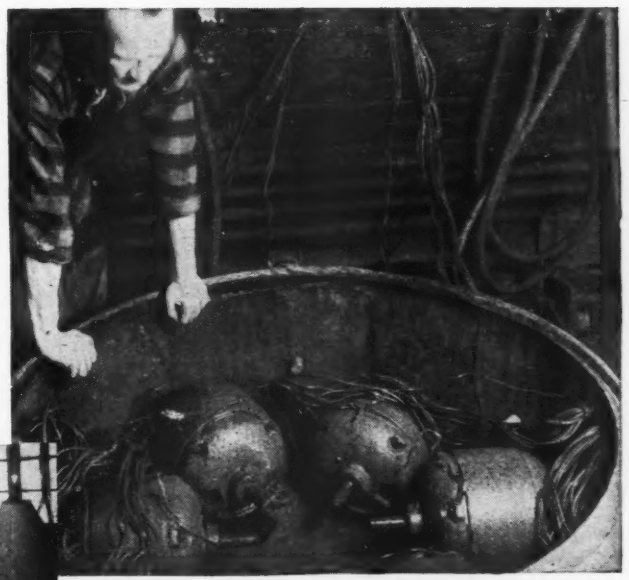
Encrusted with chemical salts, this Tri-Clad motor continues to drive a pump without breakdown of its insulation. In almost every industrial plant, motors are called upon to keep going under conditions which try their endurance to the limit. It may be in a plating room, or on an exhaust fan, or in a wet sub-cellar, or — as in this case — in connection with chemical processing. In emergencies, open motors may face conditions for which good engineering practice would require totally enclosed construction — conditions which tend to corrode the frame and attack the insulation. Endurance of Tri-Clad motors under such conditions results from tests like the one described below.

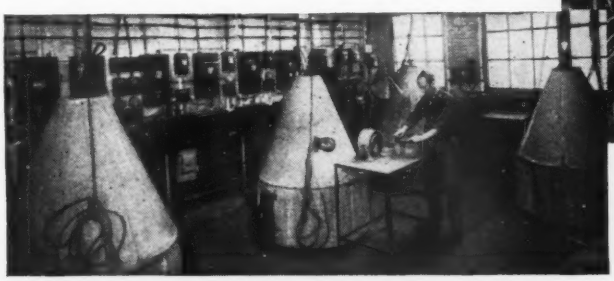
Salt-spray test of TRI CLAD motors gives assurance of long life in severe service

REG. U.S. PAT. OFF.

In this accelerated life test to determine the ultimate endurance of their insulation, the motors are operated to failure under one of the worst possible combinations of conditions. They are continually exposed to a 2% salt-water spray, while operating on a duty cycle of 3 minutes on and 37 minutes off. (These repeated voltage surges impose greater stress on the insulation than would continuous operation.) Tests are run on all new insulations developed, and as a production check on motors taken at random off the assembly lines. Because of their endurance under this severe test, among others, Formex* wire and Glyptal* bonding material were chosen for Tri-Clad insulation.

*Reg. U. S. Pat. Off.





Left: Conical hoods cover the tanks in which these salt-spray tests are conducted.

GENERAL ELECTRIC

TRI CLAD MOTORS

Every week 192,000 G-E employees purchase more than a million dollars' worth of War Bonds.

R. C. PILOT VALVES FOR POSITIVE CONTROL

R-C Unloader Pilot Valves (plain or strainer type) are standard on many leading compressors . . . installed as replacements on thousands of compressors in all parts of the U. S. A. and overseas. The R-C valve—positive in action—cannot chatter . . . it's always in open or closed position. Adjustment is provided for any unload-to-load range from 3% to 30% of maximum receiver pressure. Install an R-C Unloader Pilot valve—let performance prove its value. Specify air pressure and range of on-and-off operation desired. Write for price and recommendation.

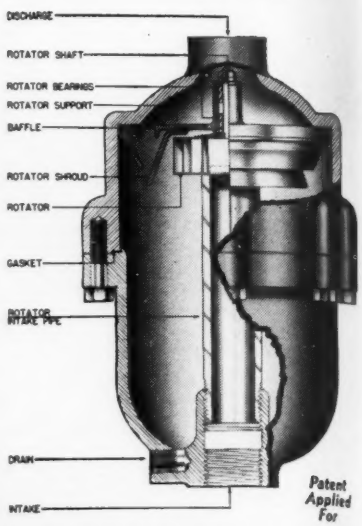
R. C. PILOT VALVE
STRAINER TYPE

R. CONRADER CO.
1207 FRENCH STREET - ERIE, PA.
PILOT VALVES for Portable and Stationary Air Compressors provided with Unloaders

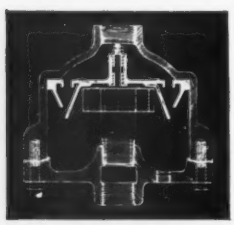
NEW TURBO-ROTOR *Pur-O-fier*

For Compressed Air

This new unit effectively eliminates moisture, oil and scale from compressed air lines. Pur-O-fier utilizes the principle of centrifugal force to separate entrainments from purified air. Once installed it requires absolutely no maintenance. Penstar Tru-Bond oiless bearing guarantees long, trouble-free operation. Manual or automatic drains provided.



Patent Applied For



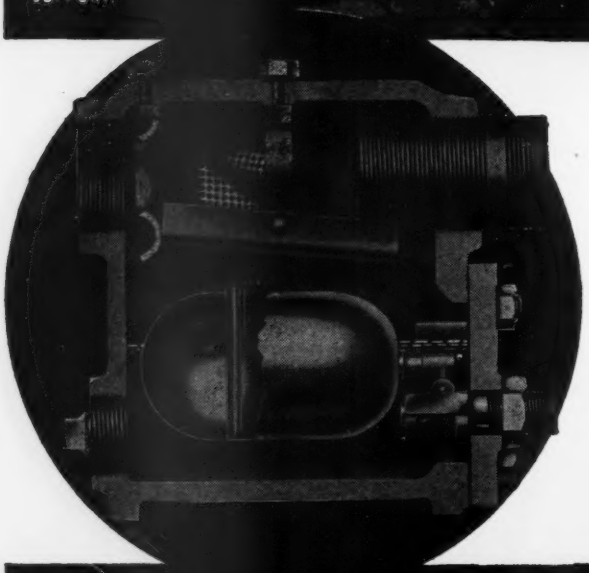
Drawing shows turbo-rotor, shroud and baffles. The design of the baffles precludes the possibility of capillary action of entrainments resulting from high velocity.

THREE MODELS AVAILABLE—A-1 will accommodate volumes from ½ to 5 cu. ft. A-2, volumes from 10 to 35 cu. ft. A-4, volumes from 35 to 100 cu. ft. Multiple units are recommended for volumes above this range. Pur-O-fier is the only standard unit that can be engineered to meet any air volume for regular or intermittent service.

BIRD-WHITE COMPANY
3120 West Lake Street, Chicago, Illinois

DRI AIR MAY BE INSTALLED BY SUSPENDING IT FROM THE PIPING WITHOUT ANY OTHER SUPPORT.

INCREASED PNEUMATIC EFFICIENCY WITH THIS AUTOMATIC SEPARATOR



A TYPICAL INSTALLATION SHOWING DRI AIR STANDING ON A CONCRETE FLOOR NEXT TO THE WALL.

PROTECT EQUIPMENT WITH

DRIAIR

SEPARATES • COLLECTS • DELIVERS

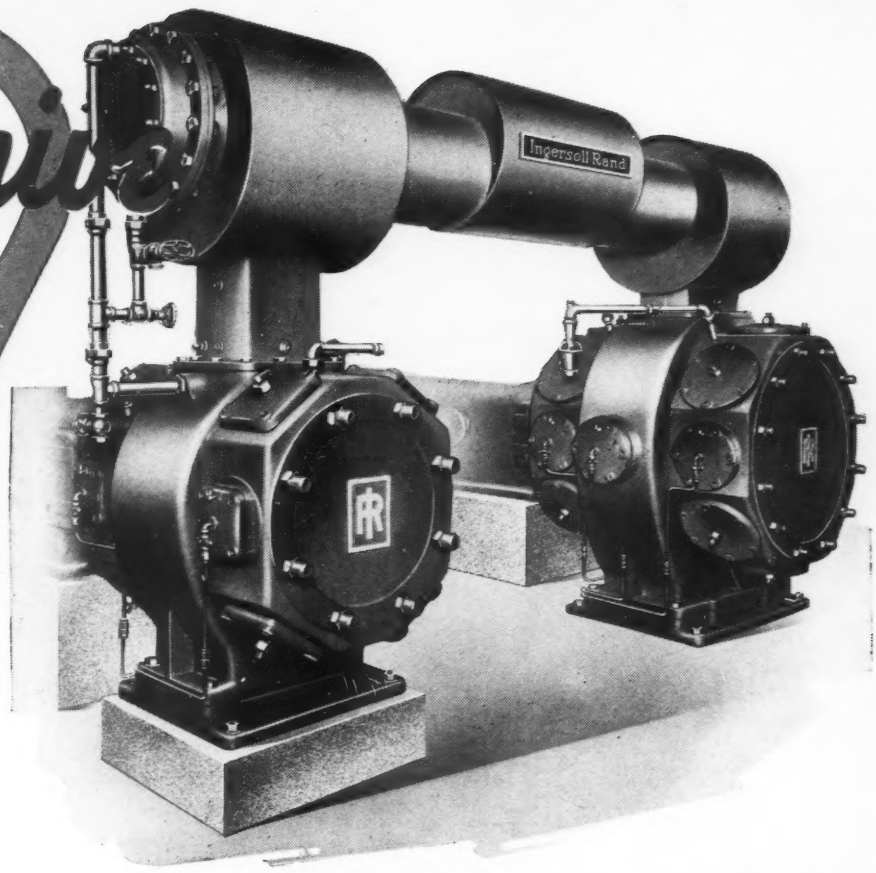
• DriAir separates and automatically ejects the condensed water and oil from compressed air lines, collects pipe scale and rust, delivers clean dry air to tools and other pneumatic equipment. This promotes better lubrication, reduces wear, increases life of tools and produces greater output. All internal parts are made of bronze or copper—resistant to corrosion and practically permanent.

WRITE FOR BULLETIN DA WHICH FULLY DESCRIBES THE CONSTRUCTION AND OPERATION OF THE DRIAIR.

NEW JERSEY METER CO.
"SPECIALISTS IN COMPRESSED AIR DEVICES"
PLAINFIELD, NEW JERSEY

Which drive?

- ELECTRIC
- STEAM
- OIL
- GAS
- BELT



THERE'S ALWAYS ONE BEST DRIVE FOR YOUR COMPRESSOR

Perhaps it's a direct-connected electric-motor which best fits in your over-all power layout . . . a synchronous motor improves the power factor.

Or it may be steam, especially when the exhaust can be profitably used in process work or heating.

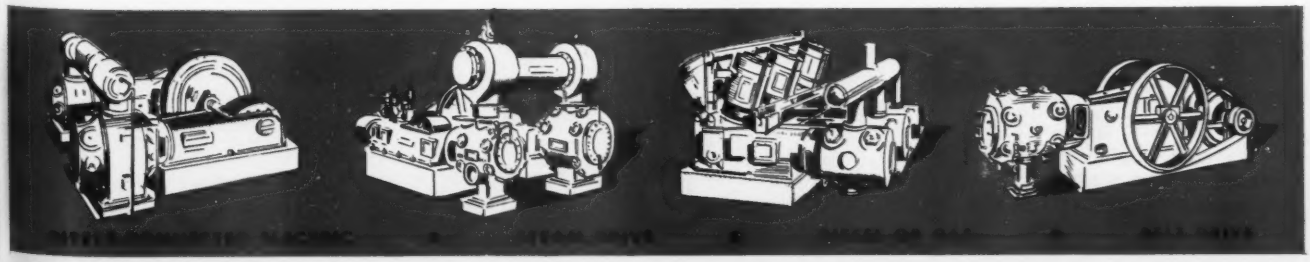
Then there are conditions best met by direct-connected oil- or gas-engine drive. In other cases, belt drive may be the correct solution.

But there is always *one best* choice, and there is no need to guess the answer. Ingersoll-Rand can furnish you compressors with any type of drive, and I-R engineers will be glad to study the problem with you, helping you select the compressor which best suits *your* conditions.

Ingersoll-Rand

11 BROADWAY, NEW YORK 4, N. Y.

1-442



Basic Tools for *INDUSTRY*

The above "inkling" of the scope of Blaw-Knox products and services must impress any industrialist with the fact that Blaw-Knox possesses skills, facilities, engineering experience of an order to make it truly a partner of industry.

For ferrous and non-ferrous industries Blaw-Knox has long produced rolling mill machinery, rolls and other basic equipment. Its leadership is equally emphatic in fabricated products for railroads, public utilities, the electronic industry and general industry. Among contractors, Blaw-Knox is synonymous with speed, efficiency and economy. In the process and chemical fields, Blaw-Knox products include all types of equipment as well as engineering and research based upon long experience.

With Blaw-Knox services and products go the *plus* value of an industry-wide background . . . of ability to think beyond the product into its ultimate uses. A discussion of your special problems is invited.

THE ILLUSTRATION presents a partial idea of Blaw-Knox Products and Services.

1 Transmission Towers
2 Radio Towers
3 Standard Buildings
4 Construction Equipment
5 Steel Forms for Concrete Construction
6 Chemical Plant Equipment
7 Rolling Mill Machinery
8 Electronic Equipment (censored)
9 Open Steel Flooring
10 Another censored line o. products
11 Complete Process Plant Units
12 Rolls for Rolling Mills
13 Prefabricated Power Piping
14 Special Castings
15 Castings for Locomotive Frames, Crossheads and Wheel Centers
16 Clamshell Buckets

Buy U. S. War Bonds and Stamps

BLAW-KNOX COMPANY

A Pacemaker for American Initiative and Ingenuity

2023 Farmers Bank Bldg., Pittsburgh, Pa.

LEWIS FOUNDRY & MACHINE DIVISION, Rolls and Rolling Mill Machinery

POWER PIPING DIVISION, Prefabricated Piping Systems

NATIONAL ALLOY STEEL DIVISION, Heat and Corrosion-Resistant Alloy Castings

PITTSBURGH ROLLS DIVISION, Rolls for Steel and Non-Ferrous Rolling Mills

BLAW-KNOX DIVISION, Chemical & Process Plants & Equipment, Construction Equipment, Steel Plant Equipment, Radio & Transmission Towers . . . General Industrial Products

COLUMBUS DIVISION, Ordnance Matériel

UNION STEEL CASTINGS DIVISION, Steel and Alloy Castings

MARTINS FERRY DIVISION, Bofors Anti-Aircraft Gun Mounts

BLAW-KNOX SPRINKLER DIVISION, Automatic Sprinklers and Deluge Systems

Four Blaw-Knox Plants have been awarded the Army-Navy "E" for war-production excellence

A FEW VICTORY PRODUCTS

ANTI-AIRCRAFT GUN MOUNTS · GUN SLIDES · LANDING BARGES · POWDER PLANTS · PIPING FOR NAVAL VESSELS · SYNTHETIC RUBBER PLANTS
CAST ARMOR FOR TANKS & NAVAL CONSTRUCTION · CHEMICAL PLANTS

AMERICA'S FIGHTING PLANES

U. S. ARMY AIR FORCES AND U. S. NAVY PHOTOS

How many of these planes do you know? Would you like a 24x37" poster illustrating them as here and giving a brief description of each one, what it does and the battles it has fought? Write on company letterhead to Koppers Company, American Hammered Piston Ring Division, Baltimore (3), Md.

The only Army-Navy "E" awarded for piston ring production

HOW *Pan American Airways* PACKS 2,100 HOURS INTO A DAY

THE minute the giant transatlantic Pan American Clippers get back to their base, they get an exhaustive going over.

It's thorough. And it's fast.

A swarm of mechanics, working in eight-hour shifts, get the job done in 60 hours — 2,100 man-hours a day.

What helps this swift turn-around are Elastic Stop Nuts. These nuts have been on every Pan American Clipper since 1928. They are on motors, mounts, wings and countless structural parts.

Particularly timesaving are the Anchor Nuts which permit smooth blind mounting. Hundreds of these fasten the covers for inspection openings. These Anchor Nuts* are an Esna development and are used by millions in all kinds of airplanes.

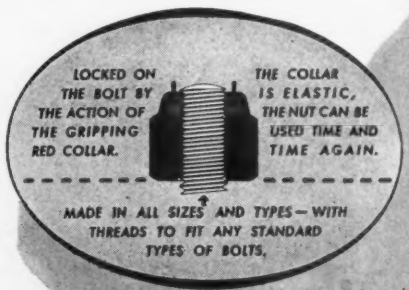
Elastic Stop Nuts lock tight and fast without any auxiliary devices. There's no time wasted in fussing to get them off and back on again.

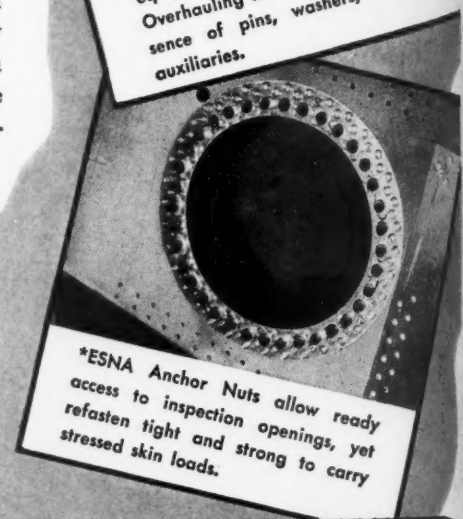
They lock because of the elastic collar in the top. This collar squeezes in between the bolt threads. It's compressed tight. The nut can't turn. It can't wiggle. It can't shake loose. And you can take it off and put it on again many times and it still locks.

Every fastened product can be better because of these nuts — can be safer, tighter, quieter, and longer lasting.

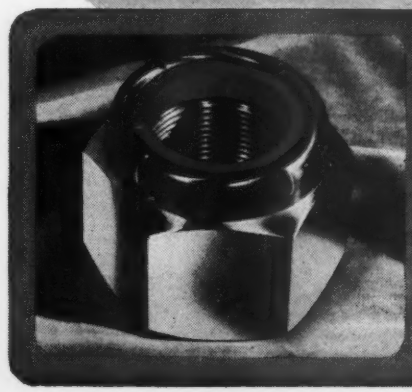
So if you have a fastening problem now, or see one ahead, let us show you how these red-collared Esna Nuts can help. Our engineers are ready to consult with you and recommend the appropriate nut.

The Clippers' powerful engines are equipped with Elastic Stop Nuts. Overhauling is simplified by the absence of pins, washers, or other auxiliaries.





*ESNA Anchor Nuts allow ready access to inspection openings, yet refasten tight and strong to carry stressed skin loads.



ESNA

TRADE MARK OF
ELASTIC STOP NUT CORPORATION
OF AMERICA

ELASTIC STOP NUTS

Lock fast to make things last

UNION, NEW JERSEY AND
LINCOLN, NEBRASKA